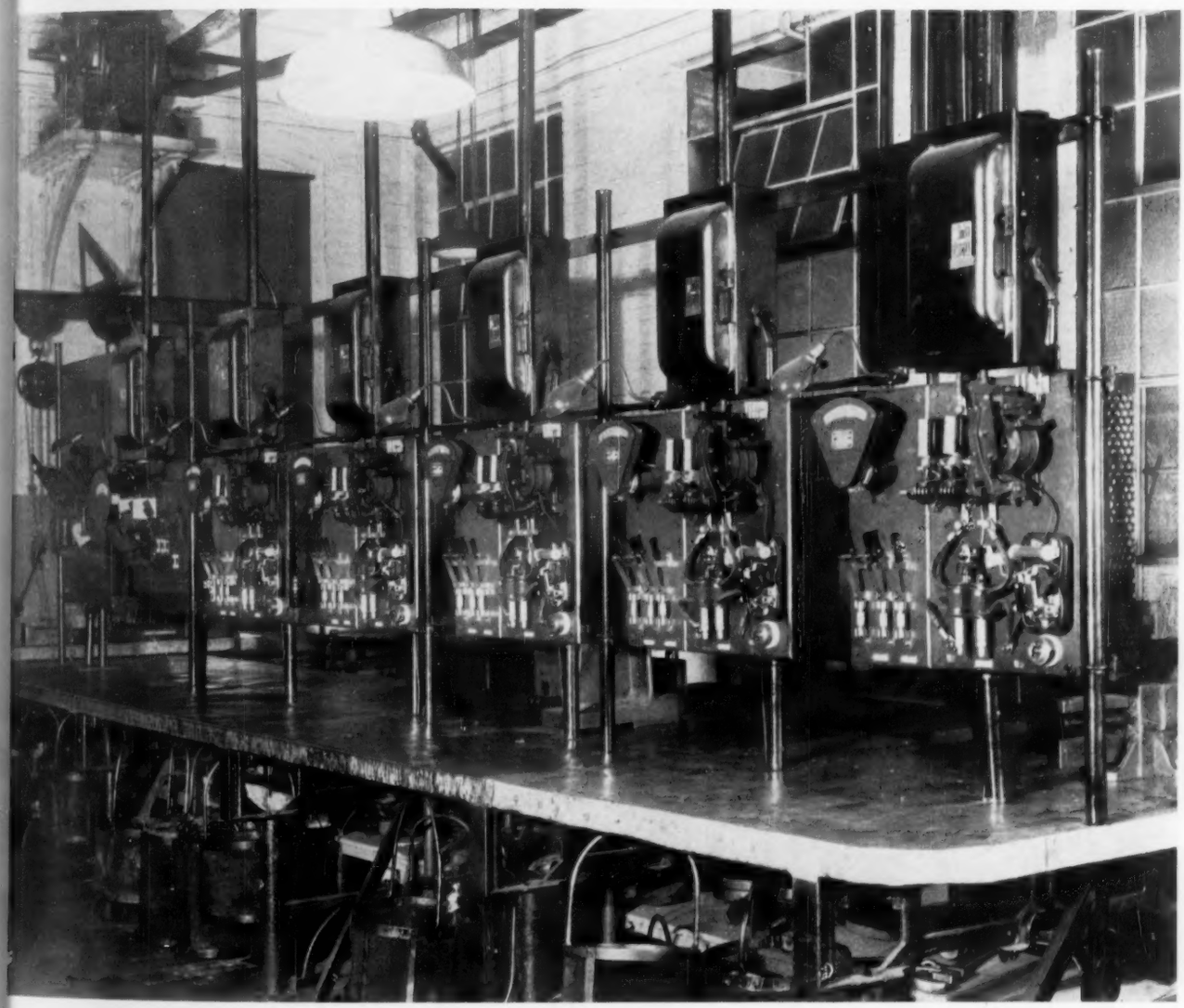
MAY 1 8 1932

INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 MAY, 1932 NUMBER 5



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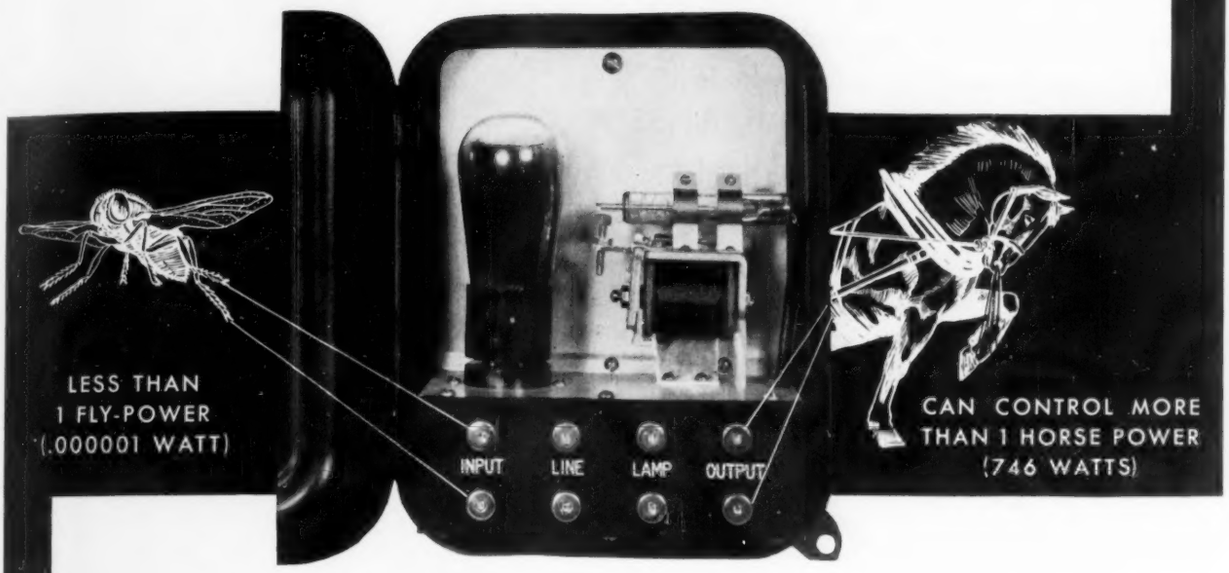

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A publication's worth to its readers can best be gaged by the breadth of its editorial service. Going too far or not going far enough are faults.

The editorial content of INSTRUMENTS is confined to articles pertaining to the problems of the man interested in measurement, inspection and control regardless of the industry he is active in at present.

INSTRUMENTS feels that the real proof of its worth lies in its ability to consistently present the highest type of information. It believes, too, that still further proof of its worth is contained in the continued enthusiasm of its readers for its contents. Such enthusiasm means for advertisers hearty response to the messages they pass on to our readers in these pages.

INSTRUMENTS is published on the fifteenth of each month.
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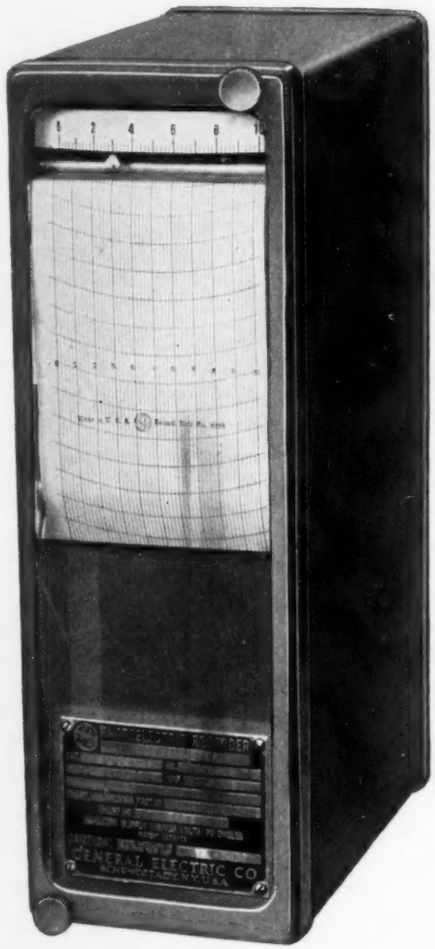

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THE MAGAZINE of MEASUREMENT and CONTROL

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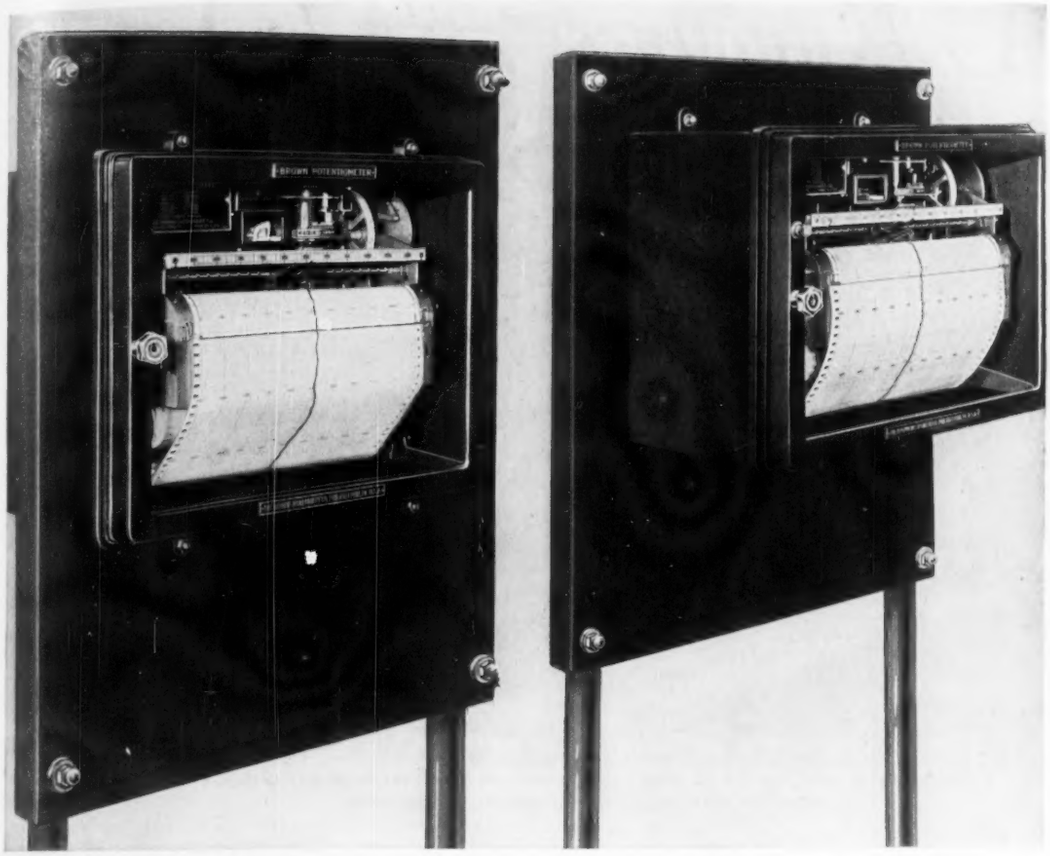

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FRONT OF BOARD MOUNTED

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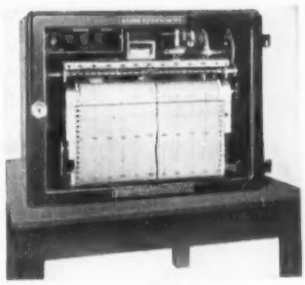

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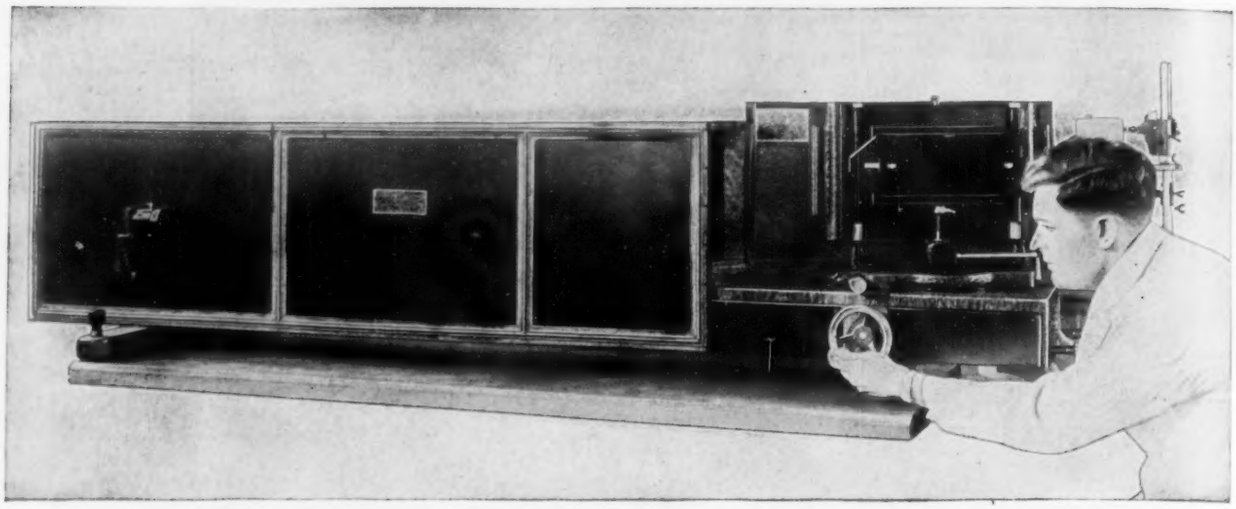

The new B & L Quartz Spectrograph, Littrow Type. Note the compactness and rigid construction. Length over all 8′ 10″. A completely replaceable set of optical parts, made of flint glass of refractive index 1.625, is offered for those whose work involves much use of the long wave-length portion of the spectrum.

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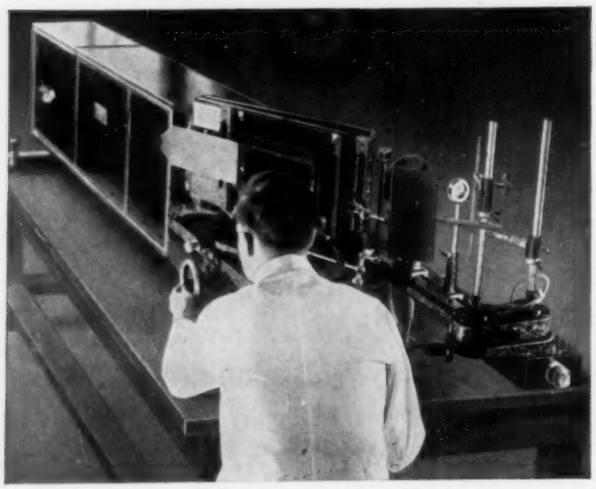
Routine analysis and control work, both qualitative and quantitative, is made easier, more economical and decidedly more valuable and effective by this new B & L Quartz Spectrograph.

Research men, control men, production men and plant executives will find the full information on this remarkable new instrument of vital interest.



Ease and convenience of operation distinguish this new instrument. The operator makes all adjustments that must be made in use quickly and easily from this convenient position.

ENGINEERING SCHOOLS

This instrument is an excellent medium for research work, for instruction in the principles of spectrum analysis and for practical work in qualitative and quantitative analysis of all metals and alloys. Send the coupon for full descriptive information.

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Send me at once complete information on the new Littrow Model B & L Quartz Spectrograph.

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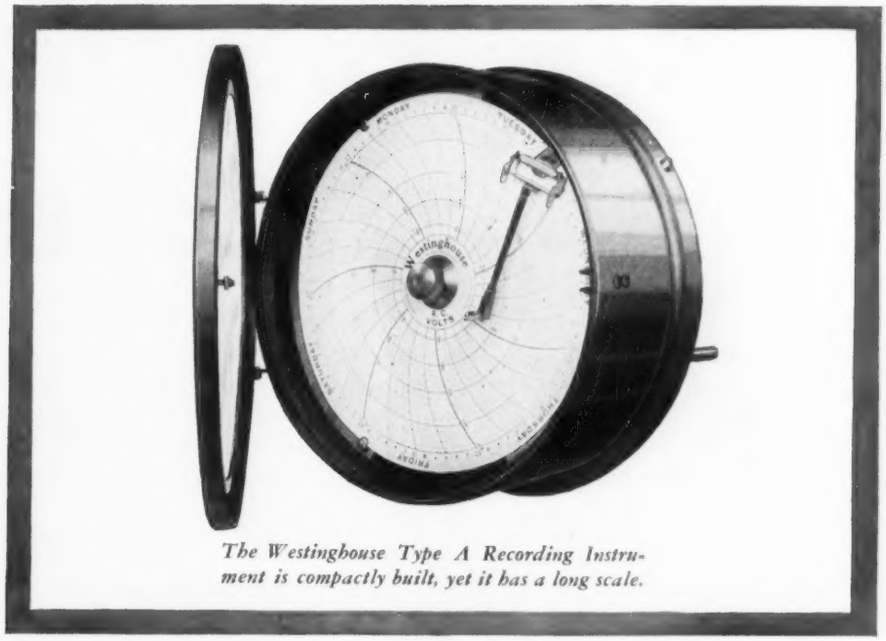
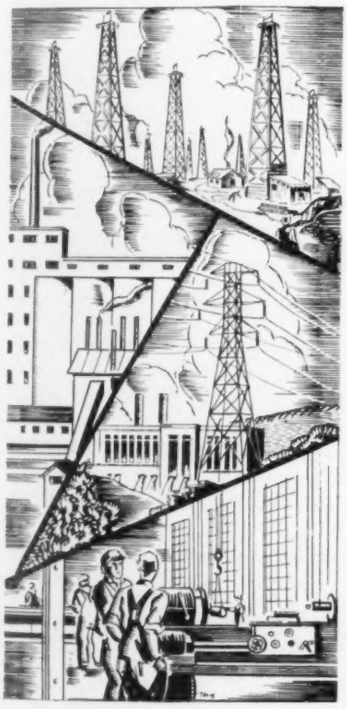


The Westinghouse Type A Recording Instrument is compactly built, yet it has a long scale.

Permanent Records at Reasonable Cost



TO keep records at a reasonable cost, the Westinghouse Type A Recording Instrument is unusually well suited for central stations, machine shops, cement mills, oil well drills, and many other fields of application.

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Type A Recording Instruments are made as ammeters and voltmeters for either switchboard mounting or portable use.

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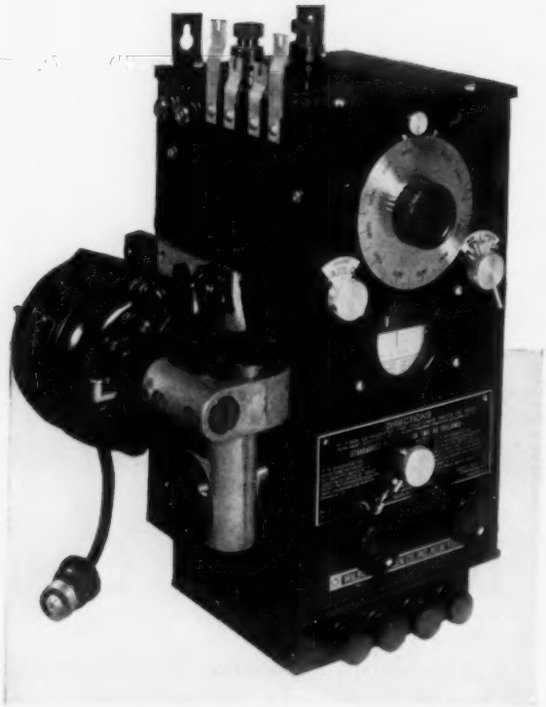
A New Potentiometer Controller . .



◆ The happy combination of certain characteristics . . . the well-known **potentiometer** method of measurement . . . the outstanding **simplicity** of the Wilson-Maeulen design . . . eight years of wide spread use of this potentiometer controller . . . PLUS the new **mercury to mercury** glass enclosed switch . . . make this controller outstanding in general industrial practicability.

◆ This controller will react to the slightest temperature change . . . giving positive accurate control. It is so simple and practical in design . . . so sturdy in construction that it will maintain its accuracy of control under the roughest shop conditions. It means better control at lower operating costs.

◆ If you use Oil, Gas or Electric heat at any temperature up to 2800° F., you should have a copy of our new Bulletin "Automatic Temperature Control Pyrometers" No. 182. Send for it today.

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EDITORIAL COMMENT

In This Issue

◆ So much excitement has been worked up about the recent arrivals in the electronic field—the photocells and the special function tubes—that it seems high time to call attention to this fact: For success in any industrial electronic application, working out the right circuit is as important as picking the trickiest tube.

Impressive emphasis is brought to this point by the article on **"An Electronic Tool of Many Measuring and Control Uses,"** which points out the many and extraordinary uses of oscillator circuits. It is brought out, moreover, that almost any electronic tube can be used as an oscillator, so that even with the common-place, old-fashioned, three element vacuum tube it is possible to do a great many unusual things in the way of measurement and control.

◆ "Work on an engineering problem is best begun where others left off." In other words, considering the vast amount of technical work carried on in the world today, it pays immensely in time, money, and effort, particularly when attacking a problem on measurement or control, to first look up what the world's technical literature has to offer on the subject.

How best to search through the world's technical literature is told in this month's article, **"Literature Research in Measurement and Control."**

◆ This month's instalment of the **Manual of Instrumentation** continues to deal with flow meters. Most of it is devoted to practical suggestions on how to install meters correctly, the material being so arranged that users and students can conveniently interpret it in terms of their own particular problems.

◆ Following **Instruments Abstracts** will keep you posted on the "current events" in your field of technical interest.

◆ ◆ ◆

The Front Cover

◆ The front cover pictures the temperature controlling equipment of six electrically heated oil baths for quenching high speed tool steels. The installation is at the plant of the Pratt & Whitney Co., and the equipment is manufactured by Bristol.

An Interesting Announcement

OUR READERS will be pleased to learn that, beginning next month, INSTRUMENTS will publish a series of articles to comprise a monograph on "Pressure (Engine) Indicators." The author of this series is Kalman J. De Juhasz, Assistant Professor of Engineering Research at the Pennsylvania State College.

Quoting Prof. De Juhasz's own words, "Owing to the wide variety of its uses, the pressure indicator is an indispensable piece of equipment in most engineering investigations involving the measurement of forces and motions. A great deal of ingenuity and painstaking research have been expended in bringing it to its present-day perfection and in adapting it to a great variety of purposes. Therefore its history, theory, construction and uses form a useful and fascinating study."

To write up this study in a series of articles there is none better fitted than Prof. De Juhasz, who has made this study his life-time interest. Moreover, he has not only contributed considerably to the literature on the subject, but has also made notable advances in pressure indicators. The best known of these is that ingenious engine indicator which bears his name.

With the publication of this valuable series, INSTRUMENTS provides one more contribution to justify its popular recognition as being more than a magazine—being rather *The* Magazine of Measurement and Control.

◆ ◆ ◆ ◆ ◆

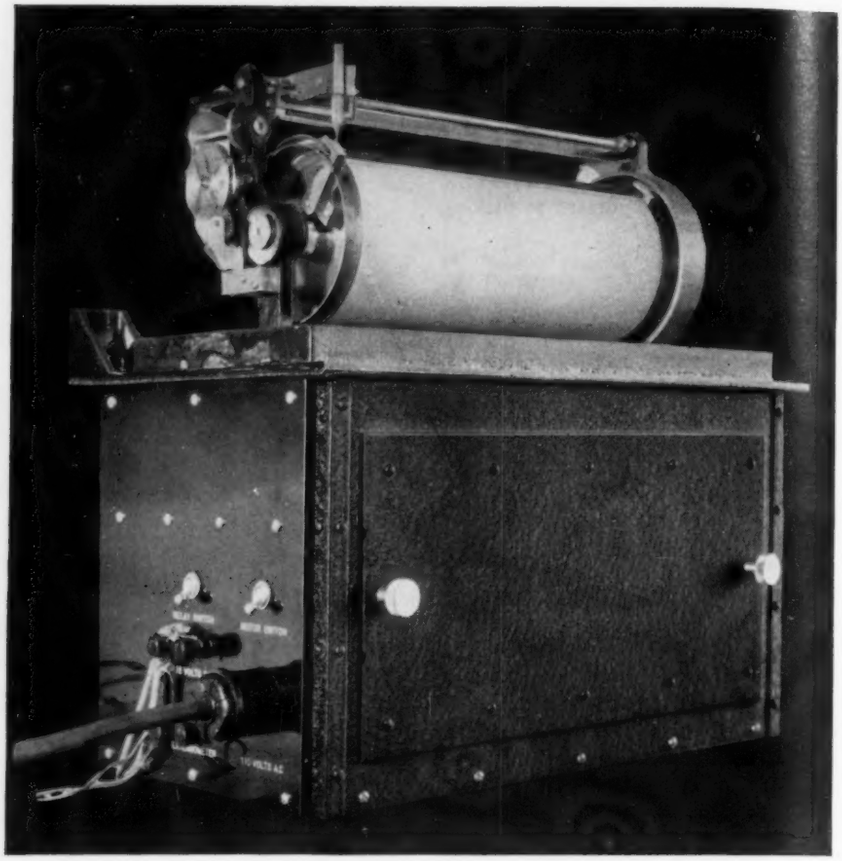
Frozen Assets

AN instrument is useful only when it is "just right" and its readings are true. When, due to carelessness or other abuses in service, an instrument is not "just right," it gives misleading readings and is worse than useless. To escape the harm from misleading readings, untold instruments in plants throughout the country are simply taken out of service and put away. No matter how slight a repair or adjustment is needed to make these unserviceable instruments "just right," unless repaired they remain useless—things of value, but things which can not be used—"frozen assets," in other words.

With so many assets "frozen" by present business conditions, the frozen assets of unserviceable instruments should by all means be thawed out. All the more so because, in most cases, these instruments require only minor repairs to make them "just right" again, and once more serviceable.

Of course the repairing of instruments should be entrusted only to those specially trained and skilled in such work. Anyone but such a specialist attempting to repair an instrument will more likely ruin it than restore it. There is no need for entrusting the servicing of instruments to amateurs. Instrument companies in general will service the units of their manufacture at reasonable cost—and in case servicing by the manufacturer is not practicable, there are, scattered in all parts of the country, a considerable number of dependable establishments which make a business of instrument repairing.

METALS WRITE THEIR AUTOGRAPHS



"Pioneers in Engineering Achievement"

Quicker than sight or thought. A little instrument that does the work of three men and in a fraction of the time. That does it without risk of errors due to human frailty —to the inadequacy of human skill. An instrument that produces a more accurate record of stress and strain during the testing of all kinds of materials, metals and alloys. That records their capabilities with unmistakable precision to guide the scientist, the engineer and the manufacturer to new accomplishments, new economies and efficiencies through the development and use of superior materials for countless purposes.

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LITERATURE RESEARCH ON MEASUREMENT AND CONTROL

By RICHARD RIMBACH and H. OLKEN

THE old adage, "A thing well begun is a thing half done," holds a lesson of great value today to the engineer beginning to work on a measurement or control problem, for an engineering problem is best begun where others left off. In other words, when first confronted with a problem, the best thing an engineer can do is to remember that there are many engineers all over the world, who have done or are doing similar work. Somewhere, sometime, some of them have made a measurement, developed a control, or devised an instrument, which may have a bearing on the problem in hand. Oftentimes it has more than a bearing on the problem--it may even solve the problem directly. In short, with the vast amount of technical work carried on in the world today, it pays immensely in money, time, and effort, when attacking a problem, to look up first what the world's technical literature has to offer on the subject.

Certainly this view is nothing more than an expression of common sense. Yet how often is it overlooked in practice, and how vast are the sums wasted as a result in the duplication of effort, we can but get a glimpse of from the following example:*

> About 1891 a paper was given before the Iron and Steel Institute detailing experiments made with different shapes of ingot molds to get the best shape for a large forging ingot. In conclusion a certain type of ingot which had been found most satisfactory was described.
>
> There is nothing more in the literature until 1902 when another paper was read before the Iron and Steel Institute, again describing extensive tests, and the results give the very same type ingot and ingot mold. In the discussion of the paper one of the men brought out that his company had also carried on extensive work and had been using this type of ingot since 1889.
>
> In 1917 the companies manufacturing large forging ingots experienced considerable difficulty and in each case after extensive and expensive research found the same type of ingot as was discovered in 1889, 1891 and 1902.

Had a thorough search of the literature been made, the vast amount of research activity and expense for rediscovering a known fact would have been saved in 1902 and again in 1917.

All the more should a technical problem in these days be attacked first by a search in the literature on the subject, because there are already available so many and so good services to help one make such a search. Of course there have long been excellent libraries everywhere, and innumerable publications in which to look for material on a desired subject. However, the difficult part is not to dig out of what's written the information desired, but to find what has been written on the desired subject.

This is particularly true of problems in measurement and control, because a valuable method of measurement may be described in the literature of one industry, yet publications of other industries, where it could be used to as great advantage, would have nothing on it. For example, a great deal is written in journals on chemistry about analysis of combustible gas mixtures. Yet readers of power plant and gas plant publications, to whom such information is of basic interest for combustion control, would not normally come across it.

*Research in Metallurgical Literature. RICHARD RIMBACH. *Blast Furnace & Steel Plant*, Sept. 1926, pages 396-399.

Of all the aids to searching in technical literature—dictionaries, handbooks, yearbooks, bibliographies, etc., by far the best are the *abstract services*.

ABSTRACT SERVICES

Three features make an abstract service a distinctly superior source for references: In the first place, the information is classified, so one can get to the desired subject simply, directly, by a definite scheme—such as alphabetical listing of titles, listing by subjects, listing by authors, etc. Then there is the particular advantage that abstracts are added continually, so one can search all the literature up to date. Finally an abstract service gives at least a glimmering of an article's contents, so one can save considerable time and effort by learning directly if the article has a bearing on his problem beyond its title.

Of the abstract services most helpful in literature research on measurement and control, those specially devoted to these fields are worthy of first consideration.

Instrument, Measurement and Control Abstract Services

The extraordinary information service on industrial measurement provided by *The Manual of Technical Measurement* (Archiv für Technisches Messen) will surprise and delight many an engineer and plant operator.

It is a new publication, brought out to give the engineer, plant manager, or scientific worker a complete story on the latest developments for meeting a measuring problem in his sphere. Recognized experts on different subjects gather the valuable information scattered throughout the current technical literature of the world, organize it so that the data on a single subject are correlated and presented in the most effectively useful summaries. Besides a comprehensive, up-to-date treatment of the latest principles or methods involved it also presents the apparatus to use, and enough about its properties and characteristics for the reader to operate that apparatus successfully.

The manual will comprise a series of about 60 reports brought out in the course of 5 years. Each report contains a number of summaries, each of which is a complete theoretical and practical treatment of one subject, by an authority on that subject. The reports are decimally classified, alphabetically indexed, and come ready for loose-leaf filing. Any subject can therefore be found quickly and easily. Each report is dated, and in fields where progress is rapid, timely revisions will be published with the latest information, thereby keeping the manual completely and constantly up to date.

The summaries are published as general descriptive articles issued on "text pages" which explain units, definitions, and incidental regulations for the respective instruments. These pages are followed by publications of new measuring methods and measuring devices. Further, supplementary sheets are issued giving information of manufacturers on their instruments with regard to types obtainable and performance. These supplements are classified and inserted like the other sheets.

Published in German, this manual is called *Die Archiv für Technisches Messen*. The editor is Dr. Ing. George

A Library on Aluminum (Aluminum Company of America).

The Battelle Memorial Institute Library is devoted to Metallurgy and Fuels.

Keinath, honorary professor of electrical measuring technique at the Technical University of Berlin, and author of numerous works on electrical measurements.

Instruments Abstracts is a regular monthly feature of *Instruments*. It is probably the most complete abstract service covering measurement and control. Over 700 publications, both domestic and foreign, are covered by 56 abstractors. In addition to this very complete coverage of the field, *Instruments Abstracts* service is notable for several other features. To begin with, consider the classification—by fields of reader interest. Anyone interested in electrical lines has but to follow section 4 and he finds there all the "current events" in his field. Then also, besides the practical branches of measurement and control (see particularly section 2) the theoretical branches of these fields are covered in section 1. Furthermore, not only are both the theoretical and practical in methods of measurement and control presented, but the operating equipment for controls—control functioning equipment—are included in the scope of this abstract service.

Upon receipt of the abstracts they are checked against permanent files to avoid duplication, and after being rewirtten to conform with *Instruments'* style they are classified. There are usually at least two places where an abstract might fit, sometimes even more, and so an effort is made to decide who will be most interested in the article. The aim is to have the abstracts so arranged that if a heat treater reads only section 2.06 he will keep in touch with all the important articles on temperature, measurement and control, and if a boiler room supervisor will read only section 2.07 each month he will not miss anything important in his field of heat and combustion.

It will amply repay engineers to glance through the whole abstract section. This takes but a short time, and the time so taken will be found very profitably spent.

A good current literature review, called "Abstracts of Articles Relating to New Instruments and Methods" appears in *The Review of Scientific Instruments*. This periodical is published monthly by the Optical Society of America in coöperation with the Scientific Apparatus Makers of America, and is edited by Dr. F. K. Richtmeyer. The abstracts are more in the field of scientific, rather than industrial measurements, and are unclassified, but each one is quite complete.

Of very much the same nature is the abstracts section of the *Instrument World* (London). This publication also carries a review of British patents, in which are listed both applications and patents granted.

Likewise *Die Messtechnik*[1] carries monthly reviews of current literature well classified, also reviews of recent books, and recent patents in the fields of measurement, testing, and control.

Quite extensive abstracts of random items are published monthly in the *Zeitschrift für Instrumentenkunde*[2] in a section called "Berichte." This journal is published in coöperation with the Physikalische Technische Reichanstalt, Berlin, Germany.

General Abstract Services

Some abstract services cover such general fields that much material on measurement and control is included in them. This is particularly true of *Science Abstracts, Chemical Abstracts,* and the *Technischen Zeitschriftanschau.* In spite of their wide scope, these services present such adequate abstracts, and are so well classified, that one can find directly the material of interest to him, and what it amounts to.

Industrial Arts Index gives only the title, and *Engineering Index* gives little more than the title of a reference. They are therefore not basically abstract services, but are very useful for a preliminary search to see what literature is available on a desired subject.

Abstract Services in Special Fields

Abstract services confined to one particular technical field have been established in many branches of science and industry. A few that can be very profitably consulted on measurement or control subjects are the following:

The Wireless Engineer and Experimental Wireless (London) each month carries a very extensive section of abstracts on radio and allied fields. The abstracts are classified, and most of them quite complete. They are compiled from journals in a great many fields and many languages by the Radio Research Board.

Physikalische Berichte is a German abstract service of very extensive scope in physics, of which a separate

(Continued on page A16)

[1] Edited by L. Litinsky and published monthly by Verlag Wilhelm Knapp, Leipzig, Germany.
[2] Published monthly by Verlag Julius Springer, Berlin, Germany.

An Electronic Tool of Many Uses for Measurement and Control

By H. OLKEN

If there can be such a thing as a "jack-of-all-trades" to serve the needs of industry in measurement and control, then the electron tube oscillator certainly fills that part. It will easily measure the thickness of a rubber sheet and just as easily check a gage block to less than a millionth of an inch. To read the amount of moisture contained in a sample of grain is one of its odd jobs, and it makes a regular job of revealing the moisture content of newsprint. Pressures it will measure from millimicrons to millions of pounds, and will readily measure temperatures to a thousandth of a degree.

By way of routine daily tasks the electron tube oscillator serves to transmit measurements and control operations by carrier current, or levels elevators at desired floors at the signal of a metal flag on the elevator passing by.

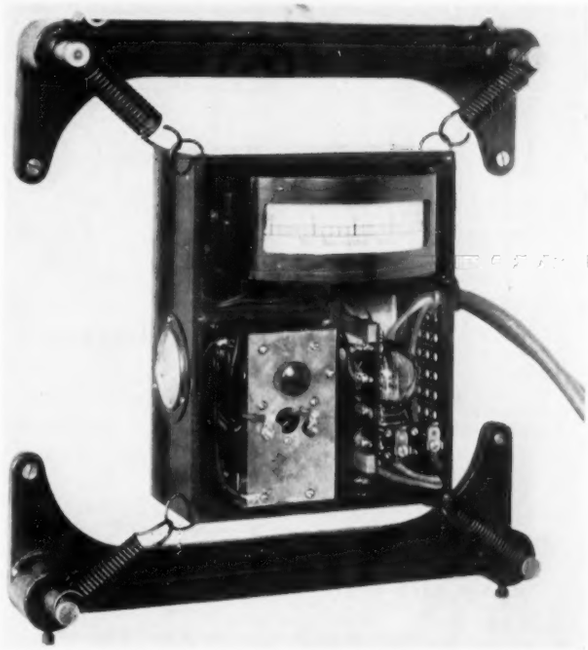
Timing is one of the jobs that the electron tube oscillator is particularly good at, for along this line it does anything from supervising the swings of a pendulum, measuring speeds of rotation, or reading the speed of a vibrating body, to measuring the velocity of a beam of light.[1]

One could go on naming the measurement and control functions of the electron tube oscillator and reach even into such fields as measuring the growth of plants. A close acquaintance with the nature and character of the oscillator will therefore be worth while.

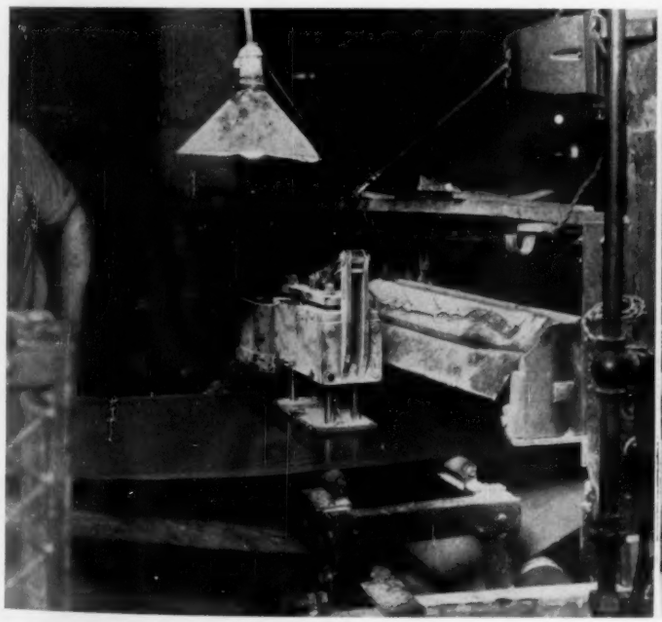
Oscillator Types and Modes of Operation

If a tuned circuit is shocked electrically, a current is produced in it that will oscillate. It is like a pendulum—strike it, and it is set swinging. The electrical impulses may be very small, but if they are applied regularly, the current oscillation is sustained. In other words, a continuous alternating current is produced in the tuned circuit.

If the electrical impulses are made to recur regularly by coupling the oscillating circuit electrically to some



Exposed View of Oscillator Unit. Indicator calibrated to read either moisture content of rubber sheeting or thickness of newsprint.



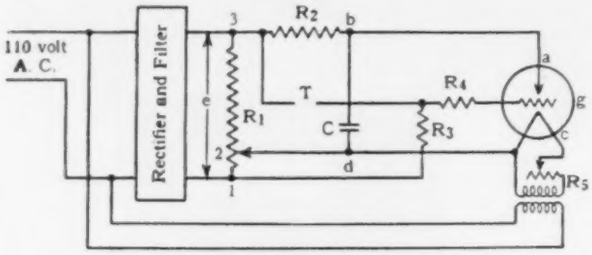
Gaging Thickness of Rubber Sheeting.

Measuring Moisture Content of Newsprint.

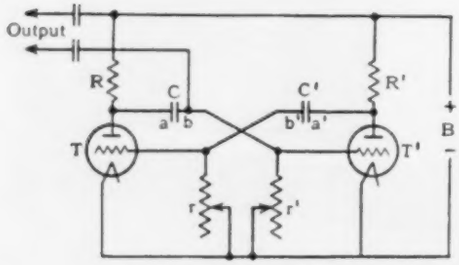
element of a vacuum tube, one has an electron-tube oscillator of the "feed back" type. The "feed-back" is usually effected by coupling through a mutual inductance or a capacity. In this category are the Hartley, Colpitts, Meisner, and other oscillators.[2]

"Electronic oscillators" are those in which impulses for sustaining the tuned circuit oscillations are kept recurring by electronic phenomena within the vacuum tube. Most prominent of these is the dynatron oscillator. A newcomer in this class is a recent development by Dow,[3] and there is an electronic oscillator known as the Barkhausen-Kurz type, which is eminently suited for oscillations of extremely high frequency.

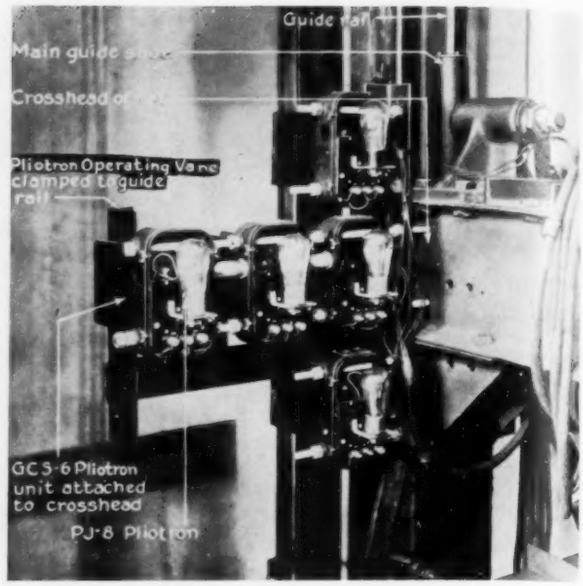
"Relaxation oscillations" are the sustained alternations of a condenser charge, rather than the oscillations of a tuned circuit. Most used of these relaxation oscillators is the multivibrator, in which the sustaining impulses are kept recurring by resistance coupling between two tubes. Recently neon tubes have been coming to the fore as relaxation oscillators.



Circuit of the stroboglow



Circuit of the oscillator



Details of Oscillator Control for Levelling Elevator Car. (Each box with tube on front is an Oscillator Unit).

The close inspection of the electron-tube oscillator just taken reveals it as merely a simple generator for alternating electrical currents. What, then, makes it capable of performing almost anything in the way of measurement and control?

Extreme Sensitivity

The answer is given by two basic facts of oscillator behavior, of which this is the first: The slightest change in the elements comprising an oscillator will alter by a large amount the amplitude or the frequency of the current it generates. Then add to this that methods of measuring alternating current amplitude or frequency are very numerous and highly refined, and no wonder the oscillator is a measuring "jack-of-all-trades." To illus-

(Continued on page A16)

Basic Unit of Stroboglow.

Oscillator of Stroboglow.

Flow Measurement and Control*

By M. F. BEHAR**

CHAPTER XXV

HEAD METERS

GENERAL

Section
1. Types of Primary Elements — *Feb.*
2. Location of Primary Elements — *Feb.*
3. Connecting Piping — *Feb.*

THEORY OF MEASUREMENT

4. Relation of Rate of Flow to Differential Pressure — *Feb. & Mar.*
5. Density Factor — *Mar.*
6. Limitation of Head Meter Formulæ — *Mar.*

PRIMARY ELEMENT DESCRIPTIONS, ETC.

7. General Considerations as to Commercial Devices — *Apr.*

PRIMARY ELEMENT DESCRIPTIONS, ETC.

Section
8. Venturi Devices — *Apr.*
9. Flow Nozzle Devices — *Apr.*
10. Orifice Devices — *Apr.*
11. Installations — *In this and coming issues*
12. Pitot and Miscellaneous Devices — *In this and coming issues*

INSTRUMENT DESCRIPTIONS

13. Indicating (Glass Tube) — *In this and coming issues*
14. Indicating (Dial, etc.) — *In this and coming issues*
15. Recording and Integrating (Manometer) — *In this and coming issues*
16. Recording and Integrating (Elastic-member) — *In this and coming issues*

10. Orifice Type Elements Commercially Available

(Continued)

Another device for quickly changing orifice plates without interruption of flow, is the "BJ" Duplex Orifice Fitting (Byron Jackson Co.) which, as its name indicates, contains two plates. One of these may be a blank plate, in which case the device may be used either as an orifice primary element or as an emergency valve. (In cases of discontinued gas service, blank plate may be locked in closed position, affording a tamper-proof shut-off.) Up- and down-stream meter connections may be made ½ in. or 1 in. from orifice plate. Two patterns are made—one for pressures up to 150 lb., the other for pressures up to 500 lb. The device is supplied "with operating wrench and two orifice plates bored to any specified diameter." Further details:

Plates are made from either mild plain steel; from stainless steel; or from bronze. There is no stress on the plate as it seats and is held in place. An indicator tag (3) is furnished with each plate to show the diameter of the orifice in metering position and of the one in reserve. The seat for the plate is accurately bored at the time the main bore is cut in the fitting. Concentricity and perfect sealing are secured as the plate is held against a cam surface at the bottom and the shut-off valve (4) exerts a similar firm wedging action on the top of the plate. There are no set screws or bolts to adjust. The shut-off valve (4) is of the pressure-seal, wedge type, constructed of bronze, and requires no lubrication.

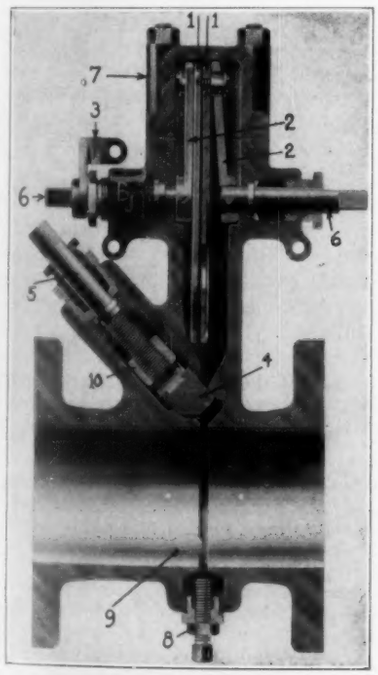


Fig. 25-52

1, 1. Orifice plates
2, 2. Cranks
3. Indicator and Locking Arm
4. Shut-off Valve—Backed off when switching plates. Also used when Cap (7) is removed for removing plates.
5. Valve Shaft
6, 6. Crank Shafts
7. Cap
8. Drain Plug and Kick-out Screw
9. Plate Locking Pin
10. Equalizer

To Install—Each BJ Orifice Fitting is furnished with two plates (Part 1) bored as ordered, and is ready to install in the flow line. Each plate is attached to a crank and cam arrangement (2) in the upper chamber, and provided with an indicator

*Part VI of *The Manual of Instrumentation.*
**Engineering Editor.

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1—Light weight! Compact!

2—Fast! CO_2 reading in 30 seconds by steel wool surface method of gas absorption. Complete analysis for CO_2, O_2 and CO in four minutes!

3—Toncan iron spot welded case, highly corrosion-resistant.

4—Monel Metal needle valves! Renewable nickel needle valve seats!

5—Cleaned in two minutes. All parts readily accessible.

6—Glass parts arranged to prevent breakage. Heavy one-piece moulded glass absorption pipettes attached to moulded hard rubber chemical bottles with soft rubber gaskets and finger compression nuts. All parts easily renewed in the field.

7—Can be carried in any position without spilling or mixing the solution.

8—Convenient reels for rubber hose prevent kinking. More than 30,000 HAYS FLUE GAS ANALYZERS now in use all over the world.

Check the coupon for literature desired.

☐ Combustion Recorders.
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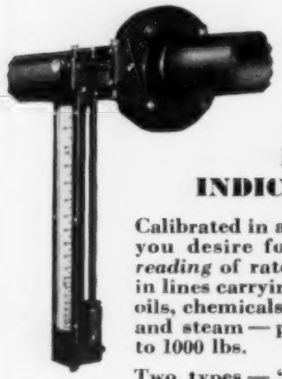
☐ Treatise on "What Flue Gas Analysis Tells Us."

The Hays Corporation
MICHIGAN CITY, IND.

INSTANT KNOWLEDGE
of your flow conditions
with the



MJL
FLOW INDICATOR

Calibrated in any units you desire for *direct reading* of rate of flow in lines carrying water, oils, chemicals, air, gas and steam — pressures to 1000 lbs.

Close Hook-up Type

Two types — "Close" and "Remote" Hook-up.

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NO CHARTS,
ACCURATE and DEPENDABLE,
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Measurements with PYRO OPTICAL are simplicity itself. A circular optical wedge is turned until a small test mark, which can be seen in the field of vision, disappears.

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(3) to show its respective orifice. The shut-off valve (4) is backed off by applying the wrench supplied with each fitting to the valve-shaft (5), leaving the slot open to receive the plate. The wrench is then applied to the crank shaft (6) extending outside the upper chamber and the handle rotated through an arc of 180 degrees to lower the plate into the flow line. As the plate seats it engages a cam on the lower half of the bore which forces it firmly against the seat exactly concentric with the bore. The same wrench is then used to screw the shut-off valve against the upper portion of the plate forcing it in contact with the seat.

To Change Orifice—The shut-off valve is backed off sufficiently to release the plate in service; the crank attached to such plate is rotated through a 180 degree arc lifting the plate into the upper chamber. The crank affixed to the reserve plate is operated through the same arc in a reverse direction causing it to contact the cam surface in the cap of the chamber, automatically moving the first plate to one side, placing the reserve plate into vertical alignment and lowering it into the line. No tool other than the change-wrench is required.

To Remove Plates—Both plates are removed to the upper chamber and the shut-off valve screwed down until it seats. The four nuts and cap (7) are removed from the upper chamber, exposing the plates readily accessible for removal with a wrench. Should the plate ever corrode and stick after long use, and the lifting action of the crank does not loosen it readily, the plug (8) in bottom of the sediment chamber may be screwed up to serve as a positive kick-out screw for removing the plate.

"Infinitely Adjustable" Primary Elements

For installations where the rate of flow varies widely from time to time, such as measuring gas at town border stations, measuring low-pressure heating steam, and many industrial process applications, the kind of devices now to be described is splendidly suitable and appears to be free from any serious limitations as to applicability—the only general limitation we notice being that the devices now on the market are not designed for high-pressure work. An inevitable characteristic (which however is not a "limitation") is that every time the effective orifice area is changed the coefficient is altered, so that scales of indicators and of recorder charts have to be graduated arbitrarily; but the makers furnish the requisite tables, curves, etc., whereby users ascertain the rate corresponding to each given opening. The principle and general construction of these infinitely-variable orifices is apparent from the illustrations of two makes.

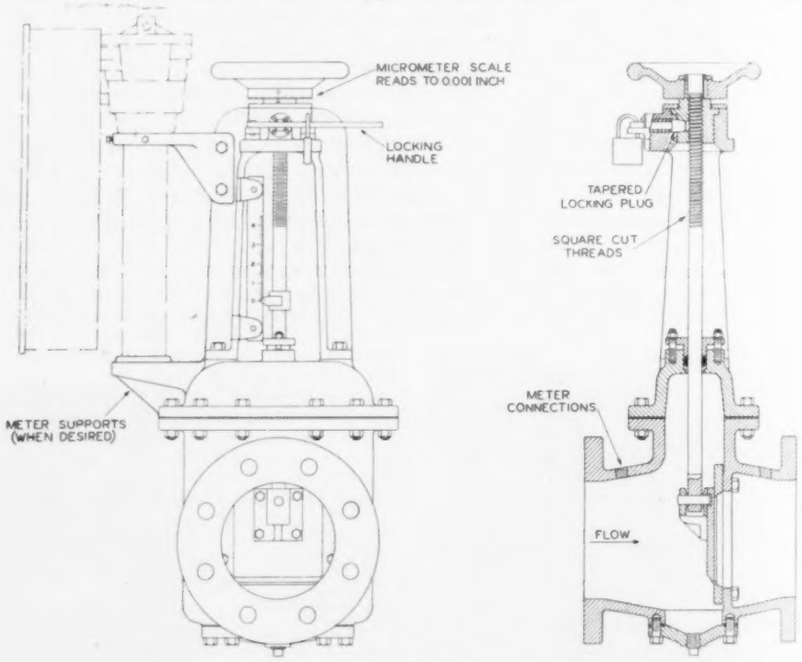

Fig. 25-53

Fig. 25-53 shows the Metric Wide-Range Orifice of the American Meter Co. An accurately machined slide moves vertically, over the face of an accurately machined circular orifice fastened rigidly in a valve body, by a handwheel rotating around a threaded rising stem of constant lead. Effective orifice area can be any value from zero to maximum, and slide position is indicated both by a pointer-and-scale and by a micrometer scale engraved on the handwheel—latter reading to 0.001-in. slide position—but provision is also made for securely locking the handwheel at zero and at each full turn, giving eighty locked positions, hence eighty fixed sizes of orifice. Maximum play between an opening and closing position when unlocked handwheel is turned is less than 0.002 in.

This Metric wide-range orifice comes in six line sizes, 6-in. to 30-in. In each size the maximum diameter of opening is ¾ of nominal pipe diameter. Machined guides hold the slide against the face of the orifice. Slide lubrication from outside by high-pressure Alemite system. Provisions are also embodied for collecting dirt and liquids and removing foreign matter through bottom.

Fig. 25-54 shows the Bailey Meter Co.'s Adjustable Orifice. It "consists of a flanged body with integral meter connections. It can be readily installed in a steam, water or gas line and connected to any differential head type of Fluid Meter. The adjustable orifice functions similarly to the commonly-used fixed type of Bailey segmental orifice. A micrometer adjusting screw permits setting the height of the gate segment within .001 of an inch. When it is advisable to change the capacity of the meter, it is simply necessary to set the micrometer screw at the reading corresponding to the desired maxi-

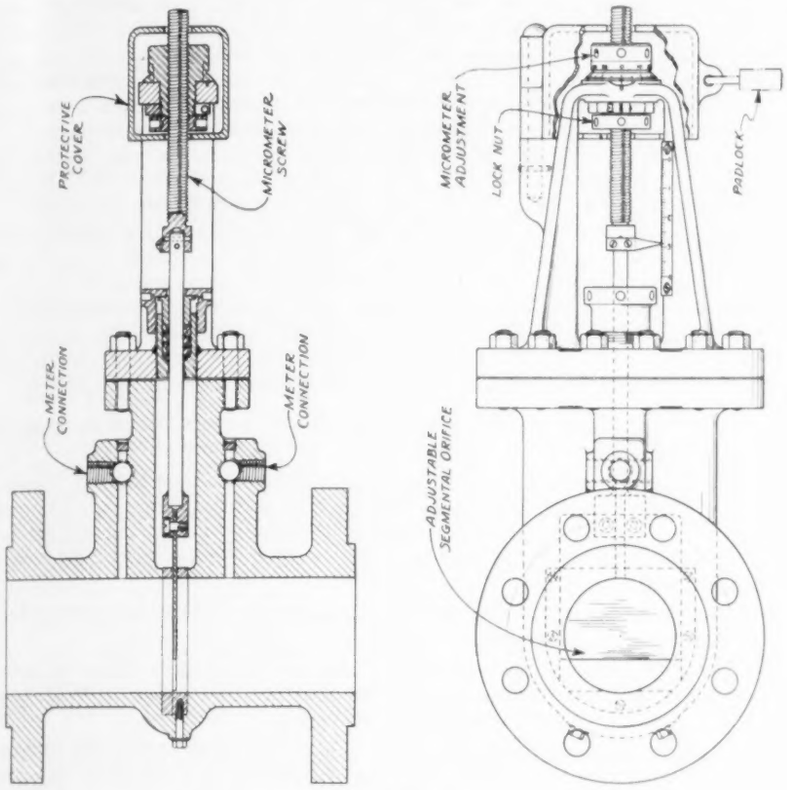

Fig. 25-54

mum capacity, as obtained from curve sheets furnished with the orifice. The Adjustable Orifice permits changing the maximum capacity of the meter as much as 40 to 1. The change may be made in a few minutes' time without disrupting meter operation or diverting the flow through a bypass line.

"Since it is possible to lock the Bailey adjustable orifice in any position desired, this feature makes it possible to correct for changes in pressure, temperature and specific gravity by slight adjustment in the Bailey meter orifice.

"Each Bailey adjustable orifice is provided with a complete set of curves showing the position required for various capacities and also showing how to make corrections for changes in temperature, pressure and specific gravity."

11. Installations

(a) Things that are "Up to the User"

For good results the primary device must produce a differential that can always be read off in terms of rate of flow. The ideal installation would be made up of a primary device that always gives a correct coefficient and a measuring instrument that always corrects automatically for variations in the properties or conditions of the fluid, such as density, viscosity, etc. Such a meter is not impossible to design and construct but it might be too expensive for general industrial use. (Some commercial meters however, do correct automatically for one or more variables.) In the actual cases of practical fluid metering which we are considering, *all factors tending to produce erratic coefficients or instrument errors must be minimized.* Experience has led to segregating the most important disturbing factors and has consequently resulted in recommendations as to pressure holes, as to certain details of construction, as to up- and downstream lengths of straight pipe, as to location and disposition of the connections between the primary device and the manometer, etc. Broad recommendations have been given in Chapter XVI (§ 8 and § 9),* and in the above § 2 on the Location of Primary Elements and § 3 on Connecting Piping. Now that various commercial primary devices have been described, it becomes

*See Part Four of the Manual, or *Instruments*, Dec. 1930, pages 765 to 774.

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

103 Shop Equipment. Catalogue No. 28, a small pocket booklet describing shop equipment for battery and electrical service. Weidenhoff, 4344 Roosevelt Road, Chicago, Ill.

104 The Graphic. Bulletin No. 2321 describes remote metering equipment. The Esterline-Angus Company, Indianapolis, Ind.

105 Furnace. Bulletin No. 460 describes a new pyrometer cone equivalent furnace. The Denver Fire Clay Company, Denver, Colo.

106 Ratio Box. Circular 1553-G illustrates the new shielded ratio box which contains in extremely compact form all the parts (except standards and detector) necessary for a one-to-one impedance bridge. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

107 Potentiometers. Circular No. GEA-1492 describes thermocouple potentiometers, and circular GEA-1536 describes new portable double bridge for measuring resistance values of 0.0001 ohm to 22 ohms. General Electric Company, Schenectady, N. Y.

108 Optical Colored Light Filter Glasses. Catalogue No. 4213 gives complete graphs of the absorptions and transmissions of the different light filters, also complete optical characteristics as to stability and homogeneity. Fish-Shurman Corp., 230 East 45th St., New York, N. Y.

109 Controllers. Bulletin No. 401 describes and illustrates precision pressure controllers. Mason Regulator Company, 1190 Adams Street, Boston, Mass.

110 Gas Burners. Bulletin 31-K describes precision gas burners for the laboratory. Also burners for every purpose and any fuel are described. Precision Scientific Co., 1736 N. Springfield Ave., Chicago, Ill.

111 Balance. Bulletin 27 illustrates the American Chain-Poise Variable-Weight Analytical Balance used for quick and accurate weight determinations. The Heusser Instrument Mfg. Co., Salt Lake City, Utah.

112 Capacitor Motor. The theory and advantages of the capacitor type motor, together with the discussion of a new oil condenser unit especially applicable to this class of service, are covered in a bulletin just issued. Another bulletin by the same company gives a simple discussion of the true meaning of power factor and how it can be corrected by static condensers in convenient, inexpensive, unit form assembled and mounted to meet any requirements. Dubilier Condenser Corp., 4377 Bronx Blvd., New York, N. Y.

113 Diagnostic X-Ray Unit. Bulletin No. 285 describes the Victor Model 17-75 diagnostic X-Ray Unit. General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.

114 Controllers. Bulletin No. 401 describes precision pressure controllers. Mason Regulator Company, 1190 Adams Street, Boston, Mass.

115 Recorders. Bulletin No. 112 describes boiler water level recorders. Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio.

116 Stop Watch Holder. A circular describing a stop watch holder, which is a convenient well-made device which protects the delicate mechanism of the watch. American Instrument Co., Inc., 774 Girard Street, N. W., Washington, D. C.

117 The Motorizer. The March 1932 issue of this publication lists answers and questions on information of interest to those interested in a.c. induction motors. The Lincoln Electric Company, P. O. Box 683, Cleveland, Ohio.

118 Instruments. Bulletin 296 covers recent developments in instrument engineering. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

119 Resistance Measurements. Catalogue No. 40 is a completely revised edition on apparatus for electrical resistance measurements. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

120 Testing Machines. Bulletin No. 28 recently released, is descriptive of Southwark Emery testing machines. Baldwin-Southwark Corporation, Paschall Station, Philadelphia, Pa.

121 Recorder. A circular dated February, 1932, illustrates an electric portable recorder, type SR for 110 volts, a.c., 25 and 60 cycle. Hoskins Manufacturing Co., 4445 Lawton Avenue, Detroit, Mich.

122 Lathe. The thirtieth edition of the book, "How to Run a Lathe." Price twenty-five cents. South Bend Lathe Works, 426 E. Madison Street, South Bend, Indiana.

123 Thermometers. A general catalogue listing and describing thermometers, pyrometers, hydrometers, barometers and hygrometers. The Philadelphia Thermometer Company, 915 Filbert Street, Philadelphia, Pa.

124 The Fog Horn. The April 1932 issue of this publications features the article, "Bringing the Mountains to Mahomet." Parks-Cramer Company, Fitchburg, Mass.

125 Water Stills. Bulletin No. 150 describes a Vulcan water still for making distilled water. Vulcan Copper and Supply Company, 126 Syracuse St., Cincinnati, Ohio.

126 The Laboratory. Volume 5, No. 2 of this publication relates the evolution of the thermometer. Fisher Scientific Co., 709 Forbes Street, Pittsburgh, Pa.

127 The Graphic. No. 332 of this publication records the operation of the New Orleans Pumping System. The Esterline-Angus Company, Indianapolis, Ind.

128 Rail Joint Tester. Booklet GA 554 explains construction and use of portable rail-joint resistance tester. This is in German. Hartmann & Braun, Frankfurt am Main, Germany.

129 Insulation Tester. Bulletin 1320 describes a new "Megger" instrument known as the wide range "Super-Meg" insulation tester. James G. Biddle Co., 1211 Arch Street, Philadelphia, Pa.

130 Illuminometer. Circular A-1 30 M Nov., 1931, describes Model 603 illuminometer, a new light measuring instrument. Weston Electrical Instrument Corporation, 591 Frelinghuysen Avenue, Newark, N. J.

131 Distribution Transformers. Folder 8248-A describes in detail the new surge-proof distribution transformer. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

132 Thermometer. Bulletin No. 377 entitled, Handy 4 in. Recording Thermometer. The Bristol Company, Waterbury, Conn.

133 Glass Apparatus. A 44 page catalogue illustrating scientific glass apparatus for the dairy industries. Louis F. Nafis, Inc., 17 North Desplaines Street, Chicago, Ill.

134 Ebulliometer. Bulletin No. 1017 describes the Tag twin ebulliometer for determining the alcoholic content of beverages and liquids. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

135 Condensers. A circular on oil condensers for power factor correction. Dubilier Condenser Corporation, 4377 Bronx Boulevard, New York, N. Y.

136 Grade-o-meter. Bulletin No. 11 describes the grade-o-meter, an instrument for mechanically testing the strength of the bond of grinding wheels, honing stones, grinding segments, emery blocks and other abrasive products. Abrasive Engineering Corporation, 2842 West Grand Blvd., Detroit, Mich.

137 Photo Electric Cells. A circular on photo electric cells. Continental Distributing Company, 43 East Ohio Street, Chicago, Ill.

138 Relays. Bulletin 81,000 describes and illustrates magnetic relays for alternating and direct current with 2-wire and 3-wire control. Ward Leonard Electric Co., Mount Vernon, N. Y.

139 Potentiometers. A circular giving the description and price on a "Queen" portable Potentiometer. Gray Instrument Co., 64 W. Johnson Street, Philadelphia, Pa.

evident that some general recommendations may be modified in the case of particular types or models—may be made much less strict in some cases. Hence the following abstracts—a compendium of selected recommendations from various sources. These shed some light, in particular, on the interdependence of tap locations and minimum lengths of straight pipe. This relation is only one of a number of questions pertaining to correct installations—one of "a number of things that are up to the user."† Among these details are some which, as mentioned above, directly affect accuracy; and others which relate to standardization throughout an industry or a particular field of metering. Such standardization has an indirect bearing on the accuracy of each individual installation because it makes for uniformity of characteristics and consequent greater ease of analysis, computations and prescription of efficacious corrective measures throughout that field. Both kinds of details are included in this section, as is exemplified in the first abstract below—that of the A.G.A. Report. This report, to be sure, is not the first set of recommendations in *any* field of head meter applications but it is the first comprehensive set for industry generally. It contains some recommendations pertaining to factors directly affecting the accuracy of any installation, as well as others tending to make for uniformly good results (in orifice metering of gases) through standardized installations.

Some of the matter in this section is applicable to Pitot installations, but this section may safely be skipped if Pitot recommendations are looked for. In fact, the requisite lengths of straight pipe, and other details, are entirely different.

A few miscellaneous notes in addition to those brought out in the abstracts which will follow:

For oils, such as pressure distillate, it is necessary to have settling chambers in the pressure piping between the meter tubing and the water seal. These are needed to keep the inside of the instrument clean and also to cut out gasification. (Builders Iron Foundry's design may be mentioned as a good solution of this problem.)

The error due to inlet conditions decreases as the ratio of inlet velocity head to that at the throat decreases.

The Venturi, having better recovery, can use smaller throats than the orifice and nozzle and therefore is less sensitive to upstream conditions. With large throats, however, the Venturi shares these errors.

Spiral flow, such as produced downstream of an elbow having the upstream flow disturbed (as by another elbow in a plane at right angle) is about the only frequently-encountered condition that seriously affects the nozzle or the Venturi if not corrected.

In contriving home-made straightening vanes remember that the main thing to be corrected is vortical flow of the whirlpool or cyclone kind. It is not the total length that matters so much as the relative length of each cell or individual passage. The length should be four times the greatest transverse dimension of any individual opening.

Do not blindly and slavishly follow rules laid down by manufacturers or by this Handbook. Exercise your judgment and make use of your knowledge of the particular conditions, in supervising every important detail of an installation.

(b) The A. G. A. Report on Orifice Installations

While enforced standardization of orifice construction and tap locations may quench the ardor of inventors when it becomes universal, it is entirely desirable and wholly unobjectionable for each industry or field of fluid flow measurement to adopt its own standards in order to bring about greater uniformity of installations and greater intelligibility of computations—not to mention greater ease of evaluating the "figure of merit" of each commercial make. An important step in this direction has been taken by the Gas Measurement Committee of the Natural Gas Department of the American Gas Association. Its recent first report* is of interest not only to the industry it serves but to all users of orifice meters. (The A.S.M.E. Fluid Meter Committee and other such

†The author is perfectly aware that some meter manufacturers have their own service engineers attend to all installation details as well as to periodical inspections and "servicing" when requested, but he has reason to believe that every reader of this Handbook appreciates the disadvantages of being entirely dependent on meter manufacturers. No self-respecting engineer or other industrial user of fluid meters can afford to neglect acquainting himself with practical details, with the result that if anything goes wrong, he will be almost helpless.

*This was not a final report, but was made with the understanding that the Committee will continue its analytical studies of the data already developed from work done by the Bureau of Standards and by the Committee and of such other data as may be developed and become available to the Committee through work done by other authoritative experimenters in this field. The Committee also will conduct further experimental work of its own. This will make necessary supplemental reports, in which the data will be summarized, the mathematical principles announced, etc.

bodies have of course issued a far greater amount of data but these are *research* bodies while the A.G.A. might be termed a form of "industrial self-government.") Extracts from the report:

Scope—This report and its specifications and recommendations relate to and should be understood to be confined to the following two types of orifice meters: (1) Orifice meters whose orifices are circular and which are to be placed concentric with the pipe line, and in which the upstream and downstream taps are placed in the flanges, commonly known as "Flange Connection" type; (2) Orifice meters whose orifices are circular and which are to be placed concentric with the pipe line, and in which the upstream and downstream taps are placed in the pipe line, commonly known as "Pipe Connection" or "Full Flow" type.

(A)—Construction and Installation Specifications:

The upstream edge of all orifices shall be square with a sharp corner and shall be maintained in such condition at all times, shall be flat and perpendicular to the axis of the pipe when in position.

The thickness of the orifice edge shall not exceed one-eighth inch, and for orifice plates with openings less than a half inch in diameter the edge thickness shall not be greater than one-sixteenth of an inch. If, to secure this, beveling of the edge is necessary, the plate shall be cut away on the downstream face and at an angle not less than 45 degrees to the axis of the pipe.

The sections of the pipe adjacent to the orifice flanges shall be as nearly cylindrical, smooth and free from blisters as it is commercially possible to obtain. The difference between the internal diameter of the pipe used on the upstream and downstream sides of the orifice shall not exceed one-half of one per cent.

Pressure Tap Locations:

For meters of the "Flange Connection" type:

The center of the upstream tap shall be placed 1 inch from the upstream face of the orifice plate.

The center of the downstream tap shall be placed not less than 1⅛ inches and not more than 1¼ inches from the upstream face of the orifice plate.

For meters of the "Pipe Connection" or "Full Flow" type:

The upstream tap shall be placed 2½ pipe diameters from the upstream face of the orifice plate.

The downstream tap shall be placed 8 pipe diameters from the upstream face of the orifice plate.

For meters of the "Flange Connection" type, the diameter of the pressure holes shall not exceed three-quarters inch nor be less than one-fourth inch. The edges of these holes on the inner surface of the pipe shall be free from burrs and should not be left perfectly sharp, but should be slightly rounded off by smoothing with fine emery cloth.

For meters of the "Pipe Connection" or "Full Flow" type, the leads from the gages to the pressure taps in the pipes containing the orifice flanges shall not be less than quarter inch pipe size. The ends of the leads should be filed smooth and screwed in just far enough to be flush with the inside surface of the main pipe.

(B)—Orifice Plate and Straightening Vanes Relative to Fittings, Etc.

If within *one hundred pipe diameters* upstream from the orifice plate the run of pipe includes anything other than flanges, collars, wide-open gates, or bends, elbows, or tees *which are all in the same plane,* then a set of straightening vanes should be placed in the pipe between the upstream pressure tap and the nearest such interruption, but not less than six pipe-diameters away from the pressure tap.

If within *two hundred pipe-diameters* upstream from the orifice plate, there is a regulating valve, regulator, differential valve, check valve, or similar flow-disturbing apparatus or fittings, vanes should be used.

The straight run upstream from the pressure tap to the nearest fitting or turn should not be less than ten pipe-diameters, and the straight run downstream, measuring from the downstream pressure tap, should not be less than five diameters.

A pressure regulator, differential valve or check valve should not be placed downstream from the orifice plate closer than ten diameters to the downstream pressure tap.

Specifications for Straightening Vanes:

1. The greatest dimension of the inside cross-section of any of the passages through the vanes should not be more than one-quarter (¼) of the inside diameter of the pipe line.

2. The length of the vanes should not be less than ten (10) times the greatest transverse dimension mentioned in specification 1.

The purpose of the vanes is to eliminate whirl, cross-currents, and large eddies, and make the gas flow straight along the pipe.

The vanes may be built of standard weight pipe, or thin walled tubing, welded together and built into a nipple to be used as a section of the pipe line, or the vanes may be built in two end rings small enough to slip into the pipe line, being held firmly in place by set screws.

If thick walled tubing is used it would be well to have the ends cut back to a thin edge.

Square or hexagonal tubes can be used in making the vanes. It is not necessary that all the vane passages should be of the same size but the arrangement should be symmetrical and approximately uniform, so that, for example, not all large tubes would be on one side and small ones on another, or a large tube in the center with much smaller ones around the outside.

Experience in the experimental work makes it advisable for the Committee to warn against a too flimsy construction of the vanes. The vane tubes should be firmly welded or otherwise strongly attached to one another to prevent their being broken up and lost in the line.

140 Graphic Instruments. Form 400 describes various devices which add to the convenience of transporting, connecting up and the use of graphic meters. The Esterline-Angus Co., Indianapolis, Ind.

141 Weights. A sheet giving the comparison of three methods of weighing—with the Hamblin accurate weigher; with the scale beams and with the weightograph. The Hamblin Accurate Weigher Company, North Olmsted, Ohio.

142 Resistors. Bulletin No. 200 describes the measurements of high voltages with high voltage resistors. Also Bulletin No. 150 describes the AKRA-OHM wire wound resistors and their application to multi-range voltmeters, ohmmeters, etc. Shallcross Mfg. Company, Collingdale, Pa.

143 Technical Instrument Bulletin. The January 1932 issue of this publication features the article, "The Busch Univertor," by F. Hauser, Ph.D. Emil Busch Optical Co., Ltd. 37 Hatton Garden, London, E.C.1, England.

144 Illium. An attractive 15 page booklet entitled, "Illium," the universal corrosion resistant. Burgess-Parr Company, Moline, Ill.

145 Rheostats. Bulletin No. 12 describes and illustrates Ohmite Rheostats. Ohmite Manufacturing Company, 636 North Albany Avenue, Chicago, Ill.

146 Meters. A booklet describing electronic meters, micro- and milliammeters, millivolt and voltmeters. Electronic Multimeters for A.C. only. Another circular by the same company describing and illustrating laboratory and research electrical measuring instruments. Rawson Electrical Instrument Company, Inc. 90 Windsor St., Cambridge, Mass.

147 Microscope. An attractive silver and black combination booklet describing the new No. 8 microscope for research. Another 8 page booklet by the same company describes and illustrates the inclinocular universal binocular microscope. Spencer Lens Company, Buffalo, N. Y.

148 Testing Machine. A circular describing the universal hydraulic testing-machine Type MP-10, for tensile, elasticity, compression, bending, folding, shearing, punching and Brinell hardness tests. Steel City Testing Laboratory, 8843 Livernois Avenue, Detroit, Mich.

149 Thermocouple Head. A circular identified as F-154-P-185-232 describes a universal thermocouple head used for base-metal thermocouples. This can be used with large or small gage thermocouple wires, with ordinary extension lead wire or protected lead wire, flexible conduit, metallic tubing or solid conduit and with any size of protection tube. Leeds & Northrup Company, 4901 Stenton Avenue.

150 Tycos. Among the feature articles of the April, 1932, issue of Tycos are: Temperature Considerations in Watch Design and Testing; How Temperature Changes Affect Life of Tires; The Invisible in Thermometers, etc. Taylor Instrument Companies, Rochester, N. Y.

151 Testing Machinery. Catalogue No. 389 describes testing machinery for paper and cardboard. Testing Machines, Inc., 314 Broadway, New York, N. Y.

152 Protective Signaling is the title of a new catalogue describing protective signaling systems for automatic sprinkler supervision, water flow alarms, manual fire alarms, watchman's service supervision of industrial processes. Howe Signal Company, Chicago, Ill.

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Swedges: Where the upstream pipe line is enlarged by a swedge so as to permit the use of large sized orifice flanges, there should be at least ten (10) diameters of the larger pipe between the swedge and the upstream pressure tap. Error in measurement due to a swedge is not eliminated by the use of vanes.

(C)—Diameter Ratio Limitation and Operating Conditions

For general use, the diameter of the orifice opening shall not exceed six-tenths of the inside diameter of the pipe. Note—If a larger orifice is needed for any measurement, it is recommended that the pipe and flanges be correspondingly enlarged so as to keep the diameter ratio down to six-tenths or less.

Orifice plates must be carefully installed so that the orifices will be concentric with the pipe.

To insure accuracy in measurement, the faces of the orifice plate and the edges of the orifice shall be kept clean.

Thermometer wells shall be placed only on the downstream side of the orifice plate and not less than three pipe diameters below the downstream pressure tap of the meter.

(c) Brown Instrument Co.'s Discussion of Special Cases

The following applies to installations of primary devices with pipe connections (whether incorporating Brown orifice plates or those of other makes) and discusses several cases met with in almost every industrial plant.

In the majority of cases, if eight pipe diameters up-stream and five diameters down-stream, from the orifice plate to the nearest fitting, the installation will be perfectly satisfactory, and a maximum accuracy can be expected. There are certain cases, however, when these accuracies cannot be expected, even though the distances specified are equal to or greater than those given in the specifications. Some of these particular fittings are listed below, with comments about their action on the accuracy of the installation:

Locating Orifice Plate on Down-Stream Side of a Butterfly Valve. If the orifice plate is located on the down-stream side of a Butterfly Valve, which is being frequently adjusted, the length of pipe diameter should be increased if possible, from the standard of eight pipe diameters to at least fifteen or twenty. If this is not done the fluctuations and swirls set up in the flow line may be such as to decrease the accuracy of the flow meter very materially.

Locating Orifice on Leading Side of a Regulating Gate Valve. The location of an orifice close to a regulating gate valve is liable to subject the Flow Meter to very large inaccuracies. The striking of fluid against the gate of a regulating gate valve will cause a very severe disturbance. The fluid striking the gate valve may cause fluctuations to travel backwards up the stream, which may cause a decrease in the differential readings, if the orifice plate is closer than 10 or 12 pipe diameters from the gate valves.

Locating Orifice on Trailing Side of a Regulating Gate Valve. The turbulent flow caused by a regulating gate valve is of course dependent upon the position of the gate, that is, the amount that the valve is open. The stream line is probably distorted 6 to 10 pipe diameters or more down-stream, depending upon the amount of opening of the valve. Allowing 2 pipe diameters for the upstream tap, the orifice should be located with at least 12 or more pipe diameters intervening between the gate valve and the orifice.

Locating Orifice on Leading Side of a Globe Valve. The stream line distortion caused by the globe valve is very severe. In a 6" pipe it has been calculated and shown that the pressure drop produced by a globe valve is equivalent to that produced by 72 diameters of straight uninterrupted pipe, while in the 12" pipe the drop produced is equivalent to about 90 pipe diameters. It is probable that the disturbance caused by a globe valve starts about 8 pipe diameters ahead of the valve. Allowing the customary 5 pipe diameters for the vena contracta and restoration of pressure, we find that at least 12 pipe diameters is required between the orifice and the globe valve. If the flow is so small that an orifice ratio of .3 or less can be used, the distance between the orifice and the globe valve can be as little as 10 pipe diameters. Under no circumstances, place an orifice on the leading side of the globe valve, with less than 10 diameters of straight uninterrupted pipe intervening.

Locating Orifice on Trailing Side of a Globe Valve. The disturbance caused by the globe valve will probably be objectionable as far as 12 or 15 pipe diameters from the valve. Allowing 2 pipe diameters for the up-stream orifice tap, we find that to be entirely safe about 20 pipe diameters should be allowed between the valve and the orifice. Where this is not possible the requirements may be satisfied with a distance of 15 pipe diameters, but a distance less than this will probably not be satisfactory.

(d) Cochrane Corporation's Set of Drawings

Another useful set of recommendations is that gotten up by the Cochrane Corp. and applying to primary devices with "integral connections," hence applying also to orifices and flow nozzles with "corner connections" such as, for example, those illustrated in Figs. 25-21, 25-38, 25-43 and 25-44. The Cochrane recommendations are given in the form of eleven drawings. We have re-arranged these in two sets: Figs. 25-56 to 25-60 apply to disturbances or fittings *up-stream or above* the primary device; Figs. 25-61 to 25-66 apply to various fittings *below* the primary device. Abstracts from the company's comments:

The ideal location of a metering element where minimum disturbance will be felt from piping arrangements is illustrated in Fig. 25-56. When impossible to select a position for the metering element as indicated in Fig. 25-56, the positions illustrated in the remaining illustrations are recommended for standard Cochrane metering elements.

Fig. 25-57. Note.—It is essential that the gate valve be wide open during the operation of the meter. Unlike a gate valve, a globe valve should not be closer than 6 pipe diameters to the metering element. Instead of 3 pipe diameters of straight run down-stream, it is satisfactory to have downstream either an elbow (Fig. 25-66), a long radius bend (Fig. 25-63), or a tee (Figs. 25-64,65).

Fig. 25-58. Note.—Instead of 3 pipe diameters of straight run downstream, it is satisfactory to have downstream either a gate valve (Fig. 25-62), an elbow (Fig. 25-66), or a tee (Figs. 25-64,65). It is not desirable to have downstream a reverse bend, for such an arrangement would probably set up a swirling action.

Figs. 25-59,60. Note.—Instead of 3 pipe diameters of straight run downstream, it is satisfactory to have downstream either a gate valve (Fig. 25-62), an elbow (Fig. 25-66), a long radius bend (Fig. 25-63), or a tee (Figs. 25-64,65).

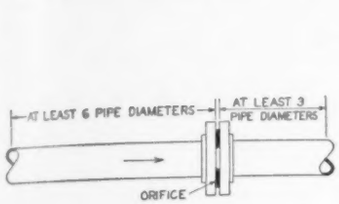


Fig. 25-56

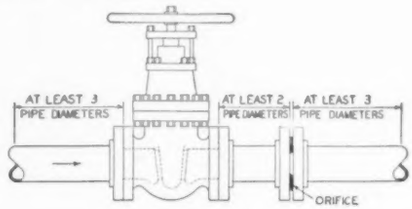


Fig. 25-57

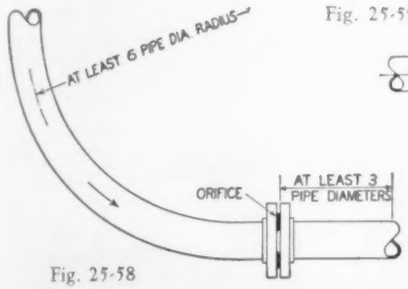
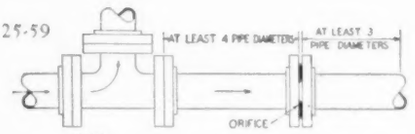


Fig. 25-58

Fig. 25-59



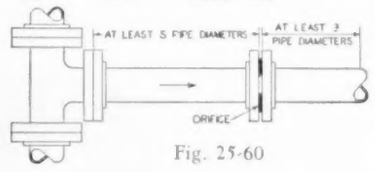


Fig. 25-60

Fig. 25-61. Note.—Unlike a gate valve, the globe valve cannot be installed close to the metering element because of the swirling action set up by the change of direction of fluid in the valve. Instead of 6 pipe diameters of straight run upstream, it is satisfactory to have upstream either a long radius bend of at least 6 pipe diameters radius, a gate valve, or a tee.

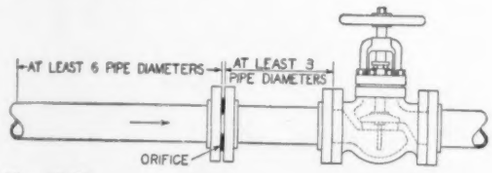


Fig. 25-61

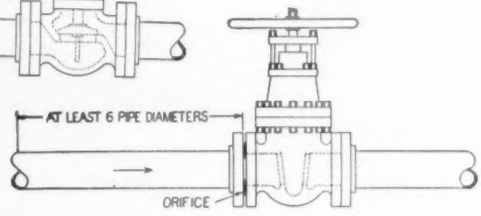


Fig. 25-62

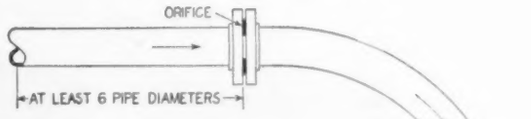
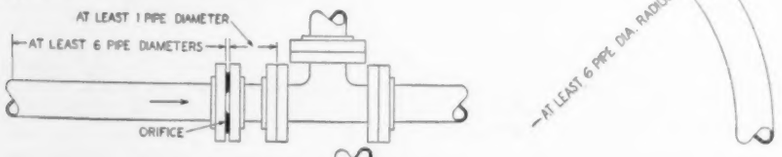


Fig. 25-63

Fig. 25-64



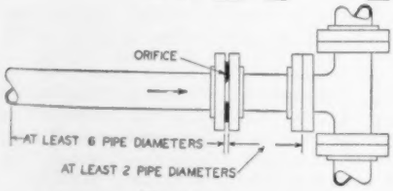


Fig. 25-65

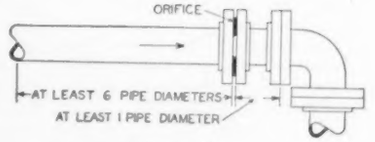


Fig. 25-66

Fig. 25-62. Note.—It is essential that the gate valve be wide open during the operation of the meter. When a flow nozzle is to be used as the metering element, the end of the nozzle must clear the gate. Instead of 6 pipe diameters of straight run upstream, it is satisfactory to have upstream either a long radius bend of at least 6 pipe diameters radius, or a tee.

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AIRCRAFT INSTRUMENT MAINTENANCE ENGINEER: Formerly Service Engineer for largest manufacturer of aircraft instruments. Especially familiar with airplane instrument problems. J-21.

Fig. 25-63. Note.—Instead of 6 pipe diameters of straight run upstream, it is satisfactory to have upstream either a tee or a gate valve. It is not desirable to have upstream a reverse bend, for such an arrangement would probably set up a swirling action.

Figs. 25-64,65. Note.—Instead of 6 pipe diameters of straight run upstream, it is satisfactory to have upstream either a long radius bend of at least 6 pipe diameters radius, a tee, or a gate valve.

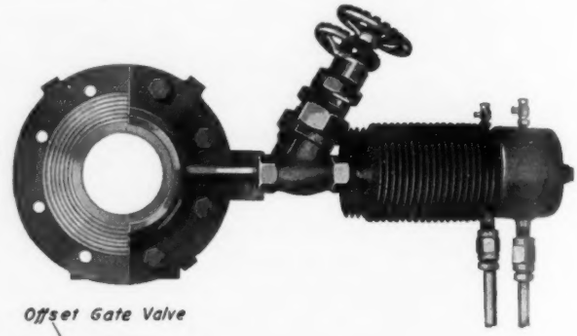
Fig. 25-66. Note.—Instead of 6 pipe diameters of straight run upstream, it is satisfactory to have upstream either a long radius bend of at least 6 pipe diameters radius, a tee, or a gate valve. When metering element pressure connections can be installed at right angles to plane of bend, elbow may adjoin metering element on downstream side.

(e) Bailey Meter Co.'s Suggestions Regarding Connections for Steam Meters

Nipples—Fig. 25-71 shows a cross section of the steam pipe showing the orifice, nipple, valve, radiator and reservoir. The nipples are specially made for the service and finished so that they will not rust. It is important that the ends of the nipples do not project into the pipe. A ring is turned into each nipple one inch from the end that is screwed into the pipe. This makes it a simple matter to determine the location of the end of the nipple in relation to the inside of the pipe. In case the nipple is to go into a fitting, it is not necessary that the end extend in far enough to be flush with the inside wall.

Bronze Offset Gate Valves—These are installed as shown in Fig. 25-71 with the stems upward and with the high side toward the pipe, so that the offset serves to trap water in the radiator. Formerly a radiator with a dam across the inner end was used, but the

Fig. 25-70



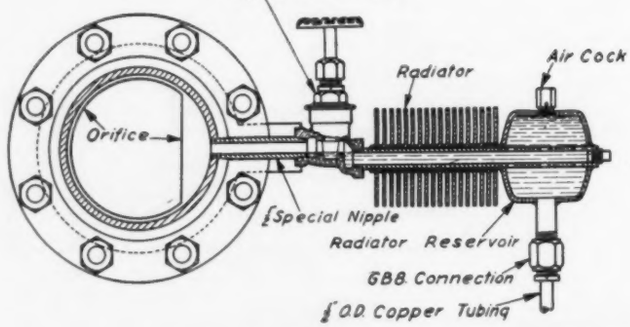
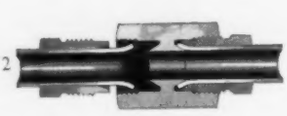


Fig. 25-71

Fig. 25-72



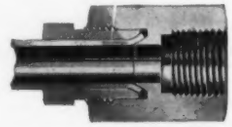


Fig. 25-73

opening was so small that it would clog under certain conditions. The large opening through the valve reduces the possibility of plugging and makes it a simple matter to clean out any deposit if necessary. (These bronze offset gate valves are satisfactory for pressures up to 350 lb. gage and intermittent temperatures of 700° F.)

Forged Steel "Y" Valves—For steam pressures from 350 lb. to 600 lb. and steam temperatures as high as 800° F, we recommend forged steel "Y" valves as shown in Fig. 25-70.

Radiators and Reservoirs—When measuring the comparatively small velocity heads or differential pressures available, it is necessary for the bell casing and the connecting pipes to be completely filled with water and the level maintained equal in both pipes, otherwise a false differential due to the unequal waterhead will result. Accuracy in following a variable rate of flow is dependent upon the rapidity with which steam can be condensed in the reservoirs, to replace that which is drawn out by a change in the position of the bell and a consequent drop in one of the connecting pipes and rise in the other. By providing sufficient radiating surface, the size of the reservoir is of secondary importance. The type of radiator and reservoir shown in Fig. 25-70 and 25-71 has proven satisfactory. The fins provide ample radiating surface, so that as soon as there is a change in the rate of flow causing a displacement of water by the motion of the bell in the meter, steam is condensed to take its place and maintain substantially

equal water levels in the two connecting lines. The reservoir is filled with water under normal operating conditions. Should air separate from the water in the connecting pipe it will rise into the reservoir and may be drawn off by means of the air cock.

Connecting Tubing, etc. This line of supplies furnished by the Bailey firm deserves mention, as encouraging correct installations. Half-inch O.D. X-H soft annealed copper tubing is one of their specialties. It comes in random lengths approximating 42 ft., is good for 800 lb. pressure, eliminates joints and fittings ordinarily required, is easy to install because neat bends are conveniently made (with a special tool or otherwise) and really cuts down the total cost of an installation. Two of the special compression fittings are shown in Figs. 25-72,73. Flaring tools are supplied.

(f) Pulsating Flow. Bailey Meter Co.'s Air Chamber Suggestions

Fig. 25-74 shows two arrangements of air chambers which may be added to water lines to reduce the pulsations caused by reciprocating pumps. To obtain the maximum effect it is necessary that the flow be directed into the air chamber, so that the air will be compressed by the inertia of the water during the impulse and then, expanding during the time of slight flow, force some of the water back out of the chamber and thus tend to equalize the flow. The left-hand figure shows the arrangement of an air chamber that may be installed by replacing an elbow by a tee and using the opening thus provided for the air chamber. In case the direction of flow is the reverse of that shown, the tee should be installed with the side outlet looking down for the discharge and with an elbow on the run looking up to make the seat for the air chamber. In the case of a straight run of pipe, as shown in the right-hand figure, it will be necessary to

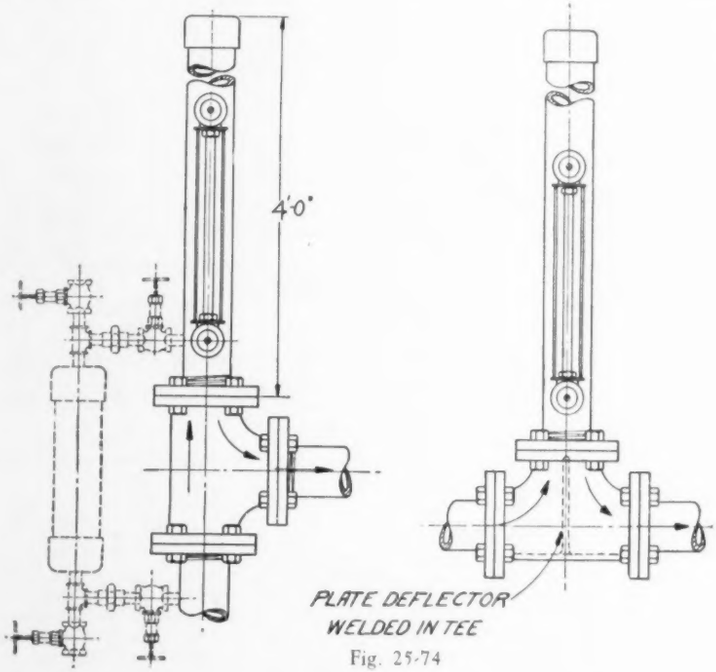


Fig. 25-74

cut in a tee with a baffle to direct the flow upward into the air chamber. An air chamber is of no use unless it is maintained with sufficient air in it to obtain the maximum effect. The gage glass is added so that the amount of air in the chamber may be known at all times. The flowing water slowly carries the air away and, unless it is watched and filled as necessary, the whole chamber will be filled with water and become useless. The usual way to fill the air chamber is to admit air into the pump suction so that the bubbles will be carried along by the water and separate when the air chamber is reached. This is much the simpler method but often causes severe knocking of the pump. When the pump suction is under pressure this system cannot be used, and unless air at a higher pressure than that of the pump discharge is available it is necessary to resort to some scheme such as that shown in dotted lines in the left-hand figure. The arrangement consists of some convenient chamber connected to the water line top and bottom with pipe and valves and in addition a drain connection at each point as shown. The cycle of operation consists of closing the valves connecting with the water line and then draining the chamber by opening the drain valves. Then, after closing the drain valves, the connecting valves are opened, when the air is compressed and passes out of the upper connection into the air chamber. The operation is repeated until sufficient air, as shown by the gage glass, had been introduced into the air chamber.

(g) Connections to Instruments Containing Mercury—American Meter Company's Recommendations

The Metric Metal Works of the American Meter Co. has drawn up a most useful set of diagrams which apply to indicating, recording, integrating and controlling instruments of the mercurial type—from the simple glass U-tube to the most elaborate instrument embodying a mercury manometer as its essential responsive element. Note how the manometer is uniformly represented in all eight installation drawings. The Metric recommendations thus are applicable

CHEMIST: Graduate Hunter College 1918. Spent twelve years working out various chemical processes in the laboratory and demonstrating them from a practical standpoint in paper mills. Work in the laboratory has included water analyses, some bacteriological work, fibre examination and testing of various materials. J-22.

ADVERTISING MANAGER: Also assistant sales manager of flow meter manufacturing company; available March 1. M.I.T. graduate Mechanical Engineer with 10 years shop, engineering, advertising and sales experience. J-23.

PHYSICIST: 2 years experience in research with particular training in atomics and electronics. Have held two fellowships. J-24.

COMMUNICATION ENGINEER: 10 years practical experience in installation, operation and maintenance of high frequency transmitters and receivers, also land line practice. Knowledge of Spanish. J-25.

ELECTRICAL ENGINEER: Experience with electric meter manufacturer and with an electrical testing laboratory. Master's degree in electrical engineering. J-26.

SALES ENGINEER: Sales promotion work on scientific instruments, industrial control, etc. Three years experience with manufacturer of scientific instruments and three years experience with manufacturer of automatic regulating devices. Graduate of University of Chicago. J-27.

ELECTRICAL ENGINEER: Graduate of University of Illinois with experience in development of control apparatus desires connection in research, design, or development of instruments or control apparatus. J-28.

MECHANICAL AND CHEMICAL ENGINEER: College graduate, experienced in general machine shop work, drafting. Three years as second assistant engineer in merchant marine. J-30.

SALES ENGINEER: Experienced in shop, service and sales. Interested in handling unit heat, ventilation and air conditioning apparatus. Licensed professional engineer. J-31.

SALES ENGINEER: B.S. degree, 1931, and graduate work in Physics and Chemistry, sales experience. Desires permanent connection with instrument manufacturer with opportunity to enter sales department. J-29.

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INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Television. Edgar H. Felix. McGraw Hill Book Co. Inc., New York, 1931. Cloth, 5¼x7¾ inches, 272 pages. Price $2.50.

In this book the author presents the subject of television with a view towards its ultimate acceptance for public and commercial service. He discusses the basic processes involved in a television system and shows how existing television systems work. He stresses the limitations and shortcomings of these systems which prevent them from being used widely for public or commercial service; and mentions the developments still needed to bring television to a point where it may be used for such service.

The author points out that all the elements of television have remained unaltered, the basic methods have undergone no radical change. However, existing systems have been subjected to an intense research and there is some reason to believe that practical television is soon at hand.

There is no doubt that television is eagerly awaited by both the public and the manufacturer. Rash promises have been made to the former by some over-optimistic publicists, while the latter are hopefully waiting for something to turn up so they may put their idle equipment to work. In the opinion of the author, before television can be accepted for public service, it must possess sufficient entertainment value; furthermore fool-proof and simple apparatus must be developed for home use. Broadcasting of sound had to await such developments and television will even more so, because in all probability the public will demand perfection nearing motion picture quality. As far as the reproducing apparatus is concerned the author is doubtful that any mechanical device will be able to reproduce high quality television. A simple inexpensive non-mechanical reproducer is needed for the home.

There are other problems which must be solved, such as those in synchronization, scanning, etc., all of which the author treats in detail. The most formidable problem seems to be that of channel limitation. Present television systems require a large group of frequencies and the present 100 Kilocycles will likely prove inadequate for high quality television transmission by any of the present methods. Means are suggested to circumvent the channel limitations as well as the other obstacles.

The problems may be solved if experimenters can break away from the orthodox methods already exhaustively investigated, and as the author says, "Obtain a fresh viewpoint."

The book is clearly written and easily understood. It is particularly recommended to those who have a technical or financial interest in television.—N. Nazar

◆ ◆ ◆

Hot Cathode Sodium Vapor Lamp

Westinghouse Electric & Mfg. Co.

A SODIUM lamp, recently developed in Germany by Dr. M. Pirani, director of research, the Osram Company, Berlin, is the most efficient light source yet developed. It has an efficiency of 70%, which is three to four times as efficient as neon light, and gives 6 times as much light for the same current as the 40-watt tungsten lamp.

to a large proportion of all industrial "pipe connection" installations (since the prescribed locations of the connections, 2½ diameters upstream and 5 to 8 downstream, are only an incidental detail). Extracts from the Metric recommendations, edited only to tie up with the figures reprinted:

Figs. 25-75,76,77. *Steam Meters*: The taps should be on a level with the center of the pipe, if the main is a horizontal line. A horizontal reservoir made from a 12-in. piece of 3-in. pipe (or a vertical reservoir 3 in. in diameter and 6 in. in length) is inserted in each of the connections from the main to the flowmeter. These reservoirs must be level with each other, higher than the flowmeter, and on a level with or higher than either of the taps in the main. The connection from the main to each of the reservoirs is ½-in. pipe or larger (1-in. pipe when the main is vertical). The tap for

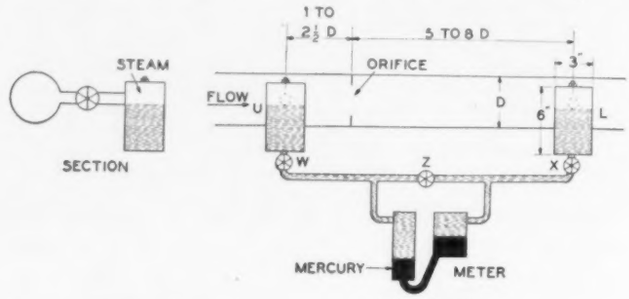


Fig. 25-75

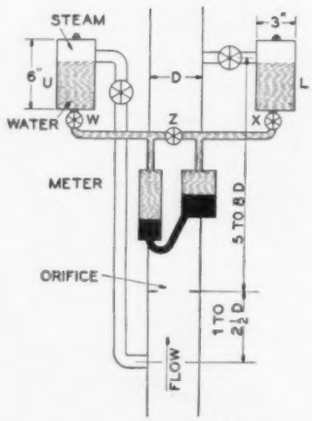


Fig. 25-76

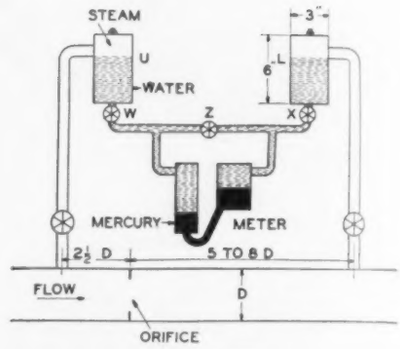


Fig. 25-77

this connection is made in the side or in the center of the end of the reservoir. The ¼-in. lines from the bottom of each reservoir to the flowmeter slope toward the flowmeter to avoid traps. A valve is installed between each reservoir and the main. When the stream is turned into the flowmeter, the lines from the flowmeter to the reservoirs, the flowmeter and the lower portion of the reservoirs will be filled with water. Additional water condensed from the steam will flow into the main. Since the taps in the reservoirs for connections to the main are on a level, the pressures produced by the liquid columns on the two chambers of the flowmeter are equal, and the pointer will indicate zero at zero flow.

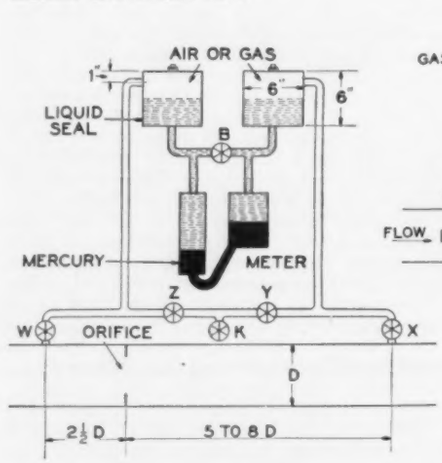


Fig. 25-78

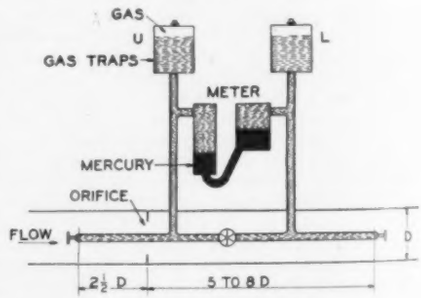


Fig. 25-79

Fig. 25-78. Special Installation for the measurement of *gases which form chemical reactions with the mercury or which corrode the mercury chambers of the flowmeter*: Reservoirs are installed above the flowmeter. The flowmeter and the lower 3 in. of each

reservoir are filled with some sealing liquid which does not react with the mercury and is not affected by the gas. As the mercury lowers in the up-stream column and rises in the down-stream column some of the liquid from the up-stream reservoir replaces the mercury in the up-stream column of the flowmeter and some of the liquid is forced from the flowmeter to the down-stream reservoir.

This installation may be used for the measurement of hot gases which condense to liquids at atmospheric temperature. In this case the liquid will fill the flowmeter and reservoirs to the inlet connections (which must be level with each other). When the differential increases some of the liquid will be forced from the down-stream reservoir and flow through the down-stream meter connection to the main. In the meantime additional condensation will fill the up-stream reservoir to the normal elevation. When the differential decreases some of the liquid will flow through the up-stream connection to the main. The connections from the reservoir to the main should be large (¾ or 1 in.) so that the liquid will flow freely and not form a liquid seal in the vertical line and produce a false reading.

Fig. 25-79. Installation for Measuring Water and Light Oils which Do Not Contain Large Quantities of Gas: The taps should be made in the side of the line. If they are made in the top of the line the connections to the flowmeter are likely to be partly filled with air or gas. If the taps are made in the bottom the connections may be filled with pipe scale, sand or other foreign matter. Fig. 25-79 shows reservoirs or gas traps for collecting air or gas which may pass through the connections. As long as the reservoirs are not filled with gas or air, the meters will record correctly. Any gas or air which may be collected can be released by opening plugs or valves in the tops of the reservoirs.

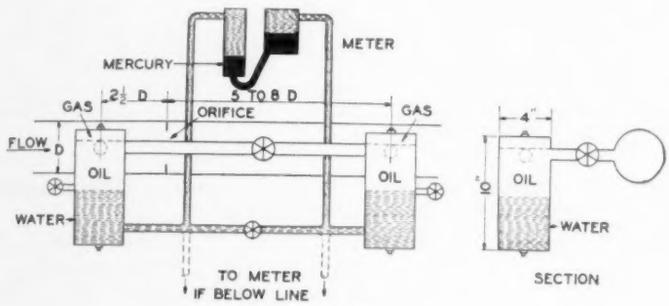


Fig. 25-80

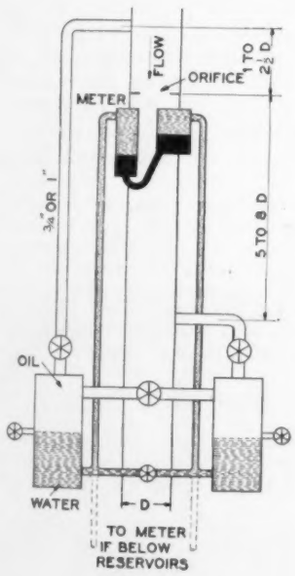


Fig. 25-81

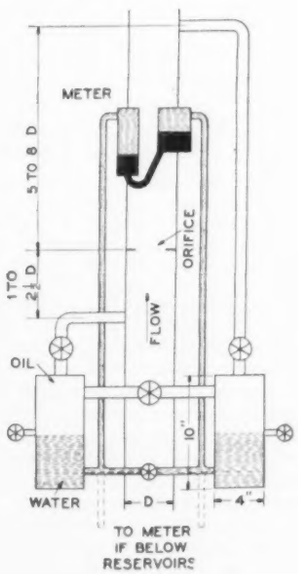
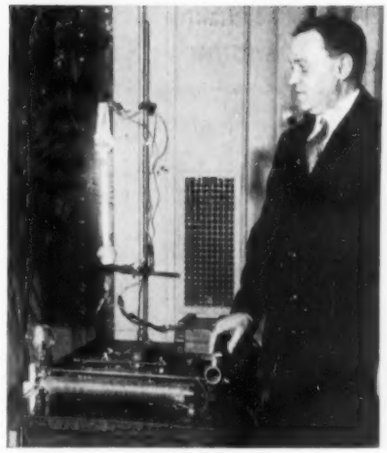


Fig. 25-82

Figs. 25-80,81,82. Installations for Measuring Caustic Solutions, Viscous Oil and Gasoline: Some viscous oils will not flow through the small connections from the main to the flowmeter. Other liquids react chemically with mercury. To eliminate these effects, reservoirs or seals are installed in the connections and water or oil is used as a sealing liquid between the liquid which is being measured and the mercury. When the specific gravity of the liquid being measured is greater than water, oil is used to fill the upper part of the reservoirs, the connections from the reservoirs to the flowmeter, and the flowmeter. When the liquid being measured is lighter than water, water is used in the lower part of the reservoirs, connections between the reservoir and the flowmeter, and in the flowmeter. The liquid which is used as a seal should flow freely through ¼-in. lines, not affect the mercury, nor mix with the liquid which is being measured.

It also is desirable to use reservoirs or seals when measuring a liquid which may contain a large quantity of gas in solution or carries gas along with the liquid. If seals or reservoirs are not used, it is possible for the gas to enter the flowmeter connections and form gas pockets which displace part of the liquid in the vertical lines and produce a



The increased efficiency of the sodium vapor lamp is due to the fact that practically all the radiation from the element sodium falls very nearly in that part of the spectrum which is most sensitive to the eye. Thus, 70% of the electric energy passed through the vaporized sodium is converted into light.

◆ ◆ ◆

Device to Measure 3,000,000 Volts

General Electric Co.

TO measure high voltages in the study of artificial lightning, ordinary electric instruments can not be used. In the high voltage laboratory of the above

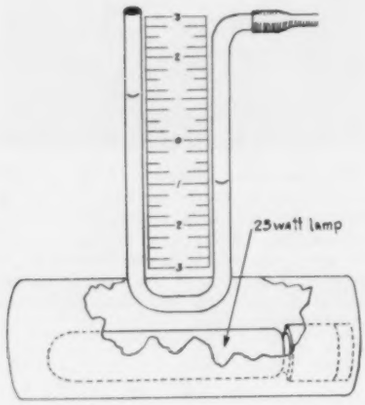
company, voltages as high as 3,000,000 were measured, using the sphere gap in the illustration. The spheres are of aluminum, of 3 ft. diameter.

◆ ◆ ◆

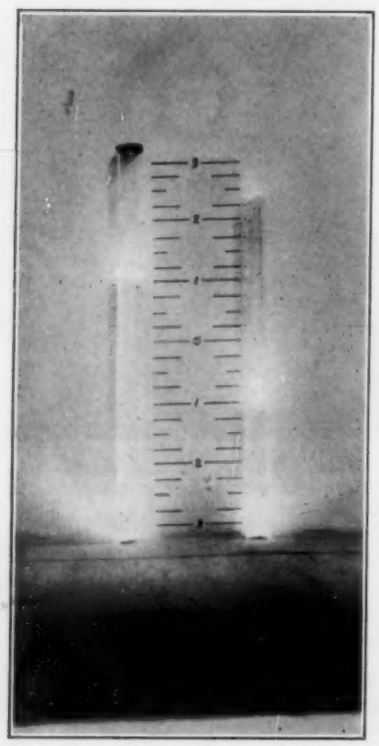
Kieley & Mueller, Inc., manufacturers of steam, water, air, oil and gas specialties, have purchased a new plant at Newark, N. J.

Illuminated Manometer Tube

WHERE difficulty is experienced in reading manometers used on inspection tests, a simple addition to the equipment facilitates the procedure. A cylindrical housing built around the lower portion of the U-tube



and containing a 25-watt T—6½ bulb MAZDA lamp supplies illumination for accurate readings. Light from the lamp is transmitted through the clear liquid in the tube, when it is intercepted by the lense-shaped meniscus it becomes distinctly visible. A manometer thus lighted may be easily read at a distance of several feet.



false reading. In each of the installations shown the reservoirs are located so that if the liquid carries any gas, the use of reservoirs will tend to prevent gas pockets in the connections. If gasoline in vertical lines is measured, large lines are used between the main and the reservoirs which are installed as close to the main as possible. These large connections (¾-in. or 1-in.) permit the escape of a gas which collects in the reservoirs or connections.

If caustic solutions are being measured, and there is a possibility that some gas will enter the line, the reservoirs may be extended to form gas traps in the upper ends of the reservoirs. The gas is released from time to time and any error is eliminated if the gas does not enter the connections to the flowmeter.

Some oils may congeal at atmospheric temperature and not flow through the small lines or if they flow they may form a thick layer of oil on the surfaces of the columns of the flowmeter. If the oil is so viscous at atmospheric temperature that it will not flow through the connections from the main to the reservoirs, the connections and reservoirs should be heated to reduce the viscosity so that it will flow freely through the ¾-in. lines from the main to the reservoirs.

When measuring hot liquids through vertical lines the connections from the reservoirs to the main should be maintained at the same temperature as liquid in the line. This is especially necessary when measuring at low differentials for the reason that the difference in density between the liquid in the line and the liquid in the connections may produce a false differential reading on the flowmeter.

The illustrations show the most desirable arrangement of fittings from the main to the flowmeter. In each and every instance the dotted lines indicate that instruments can be placed below the reservoirs or above the reservoirs.

The valves RR are placed at the middle point in the vertical height of the reservoirs and on a level with each other for the purpose of determining the height of the heavier liquid in the reservoirs when the installation is ready to be placed in operation. Ordinary visible water-gages and glasses may be used instead of valves RR to indicate the level of the liquids in the reservoirs. The by-passes between the up-stream and down-stream connections to the reservoirs are installed so that the head of sealing liquid on the up-stream side of the flowmeter can be made equal to the head on the down-stream side by opening valves B and Z when valves W and X are closed.

(h) Importance of Correct Pressure Holes in Pipe Connection Installations —the Worcester "Piezometer Investigation."

The manufacturers of head meters do not fail to recommend that holes for pipe connections be drilled perpendicularly, that burrs be removed from the edges, that these edges and the inside of the pipe be inspected if possible, that the surrounding area of the inside of the pipe be smoothed if possible, and that nipples should not protrude inside the pipe. More detailed recommendations are to be found in Ch. XVI, § 8. Experience has shown that even strict observance of these precautions—of these precautions *only*—was not sufficient for the best results. At the 1931 Annual A.S.M.E. Meeting, Allen and Hooper presented a report on an investigation by them at the Worcester Polytechnic Institute to determine a *stable type* of "piezometer" suitable for use as a standard in commercial work, and to determine those factors which have the greatest bearing in obtaining correct results.

Thirty "piezometers" were tested, 14 of them "flush" (that is to say "pressure holes"), the others "recessed" or with parts protruding variously inside the test section of the 12-in. pipe in the Hydraulic Laboratory set-up. Of the 14 flush pressure holes, some were square-edged but varying from 1/16-in. to ½-in., and others—also of various sizes, had edges with various radii of rounding. The conclusions (in which "piezometer" means the pressure hole itself or the plug or other device for taking off line pressure and "orifice" means the hole in the plug when a plug was used or at the end of the nipple or tube when nipples or tubes were flush or protruded inside the pipe) are as follows:

1. The error of a given piezometer is a constant percentage of the local velocity head existing at its orifice.
2. The size of the opening has no effect within the limits tested, which were from 1/16-in. to 27/32-in. opening and mean velocities up to 7.3 ft. per sec. in a 12-in. pipe.
3. A true square-edged orifice is accurate, but very sensitive to slight changes in construction and position.
4. A standard piezometer plug or plate must be absolutely flush with the conduit wall.
5. A piezometer that projects beyond the pipe-wall surface has a large negative error.
6. The burr must be carefully removed from a square-edged orifice.
7. A piezometer plate or plug is not sensitive to minute abrasions on its surface.
8. A piezometer orifice must continue with parallel sides for over two diameters into the plug before its shape is changed.
9. The inside penstock wall should be scraped clean for at least 1 ft. upstream from a piezometer.
10. The piezometers to determine true pressure head should not be installed where there is any chance of the water whirling in the pipe or immediately downstream from an obstruction, such as a butterfly valve, a rivet head, or a plate joint.
11. An inserted tube pointed on the upstream end and with piezometers on the side gives a correct pressure-head reading, but it is very sensitive to angularity.
12. A tea-ball piezometer has a large negative error, but it is not sensitive to the direction of the flow of the water.
13. A conical piezometer has a very large negative effect, but must be used with extreme care and calibrated.
14. An orifice with a large radius of rounding has a small positive error.
15. An orifice with ¼-in. hole and 1/16-in. radius of rounding is recommended for standard practice.

NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

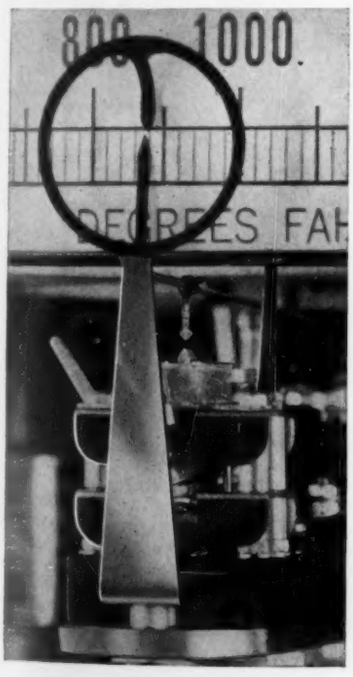
Pyrometer Controller

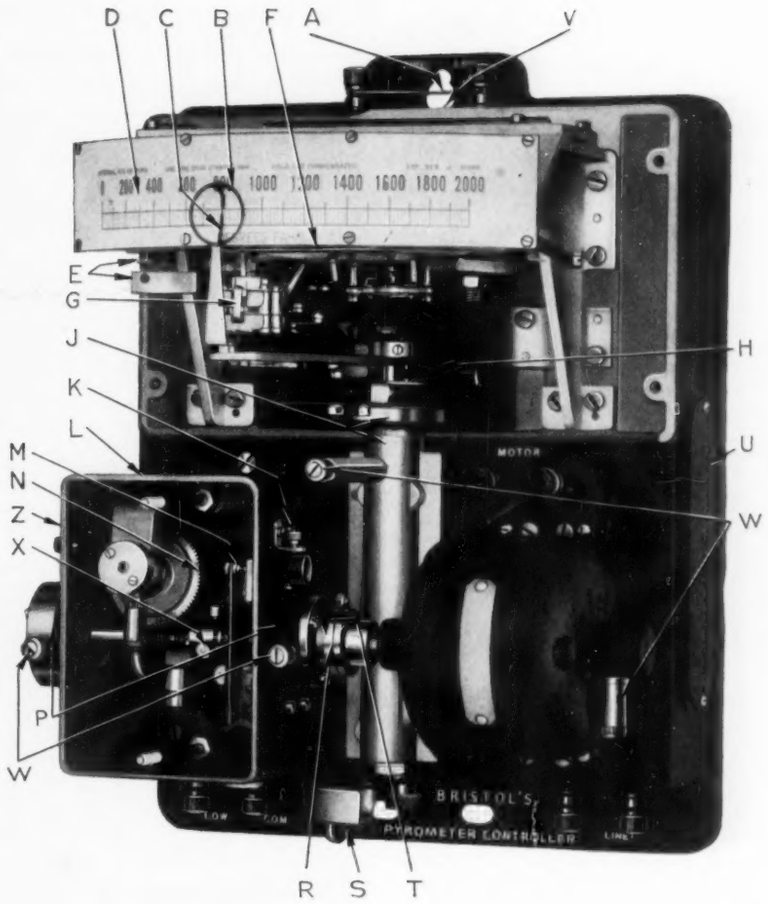
The Bristol Company

THIS automatic control pyrometer was developed to provide very close temperature control in a wide variety of temperature control applications.

The operation of the controller's basic mechanism is as follows: The pointer of the millivoltmeter movement carries a wedge shaped steeple against which the switch mechanism is periodically raised. This action operates the trip switch which makes and breaks the control circuit.

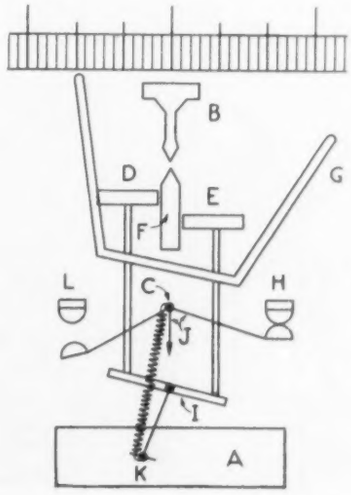
The operation of this switch mechanism is accomplished by means of a motor, driving a cam through a worm gear reduction. Once every 15 seconds, or if required, every 7½ seconds, the switch mechanism is periodically carried upward far enough so that the pointer steeple trips the switch. There is a momentary pause when the switch attains its highest position after which there is a quick return to the lowest position. Referring to the figure, the switch mechanism is attached to platform A which is periodically raised and lowered. The galvanometer pointer has steeple B attached to it. As the switch mechanism is raised, knife edge F and the steeple literally





"split degrees." As the switch mechanism continues to rise, the top of steeple B comes in contact with a stationary plate and pushes either stool D or E downward. This operates platform I, which, through extension K is connected by means of a coil spring to pivoted toggle switch J, so that when stool D is pushed downward a quick positive contact is made at L. When stool E is pushed downward, the L contact is broken and H is made. These contacts, of sterling silver, have a maximum capacity of 250 volts, 100 watts and 1 ampere. The switch in its operation moves pointer-restraining arrangement G which prevents the pointer from going past the switch without tripping it in the proper direction. The points H high, C common, and L low are connected by insulated wires to three external binding posts. The millivoltmeter movement is adjusted so that the pointer swings in a plane parallel to the course of the switch. As a result, the switch operates with certainty at any part of the scale arc. There is claimed to be no lateral thrust on the pointer and no force on the movement pivots along the pointer arm.

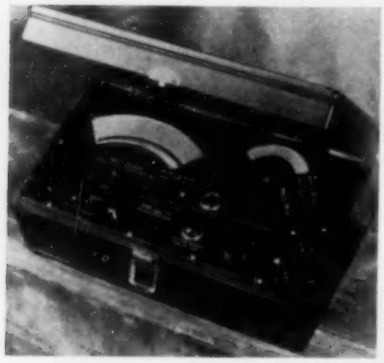
This basic mechanism is provided in several modifications adapted to different modes of temperature control. One model is adapted for time-temperature process cycles or programs. Another model differentiates between large and small changes of temperature, and initiates a large corrective action if the change is large, or a small corrective action if the temperature change is small. Where the factors of a process are subject to wide variations, a multi-speed anticipatory model controller is provided. From its detection of the *amount* of variation it selects the *speed* of corrective action. From its detection of the *trend* of variation it selects the *direction* of corrective action. This instrument is provided with adjustable features which makes possible field adjustments to fit the sensitivity to the process being controlled.

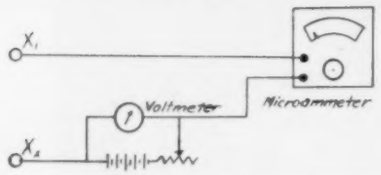


Multirange Direct Reading Conductivity Meter

Sensitive Research Instrument Corp.

THIS multirange direct reading conductivity or resistance meter was designed to provide a compact portable field instrument for measuring resistances from 5 ohms to 500 megohms, the upper ranges of the meter being far beyond that of a. c. bridges with all of their allied equipment.





It is particularly adapted for the measurement of the value of pipe coatings used in the prevention of soil corrosion. These coatings are in the form of enamels, paints or asphalt emulsions. The instrument may be used also for the measurement of soil samples in the laboratory and the resistance of "driven" and "station" grounds.

The scales are figured in OHMS and MHOS having a range of 5 ohms to 500 megohms or 0.2 mhos to 0.000000002 mhos. The instrument contains its own batteries (dry cell type) completely encased.

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Slow Motion Motor

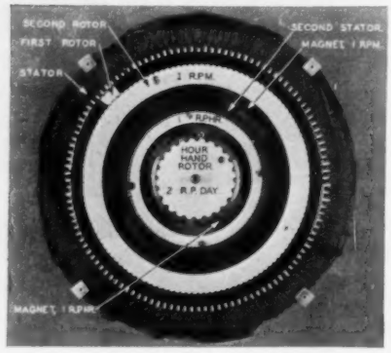
Westinghouse Electric and Manufacturing Co.

A FEATURE of great interest about this motor, which is still in process of development, is the novel "vernier rotation" principle upon which it operates. The practical application of this principle is demonstrated in the unique clock pictured here.

A rotating magnetic field is produced by suitably connected condensers and resistor in the wire-wound iron circle, known as the stator, which is just below the outer rim of the clock face. This stator is so wound as to produce a magnetic field which rotates around it 3,600 times per minute. It has 118 iron teeth around its inside edge.

Inside this ring, near it but not touching it, is the rotor or rotating portion of the motor, around the outer edge of which are 120 iron teeth. The tendency of the magnetic flux is to take the shortest path from the stator to the rotor, and in doing this exerts a torque tending to bring the teeth of rotor and stator directly opposite each other.

With different numbers of teeth on the two parts, only two teeth are synchronized at any one time and there is a vernier effect around the rest of the circle.



This causes the motor to move only the distance of two teeth for each revolution of the magnetic field.

In other words, the magnetic field is whirling around 3,600 times a minute but the rotor revolves only 60 times a minute. This is the speed required for a split second hand.

Around the inner edge of the rotor ring are 122 iron teeth pointing toward a second rotating iron ring of still smaller diameter with 120 teeth around its outer edge. In this second reduction of speed the first motor becomes the stator for the second, but while the first is running forward 60 revolutions a minute, the second is running backward 59 revolutions a minute relative to the first one, so that its net progress forward is one revolution per minute. This is the speed desired for the second hand.

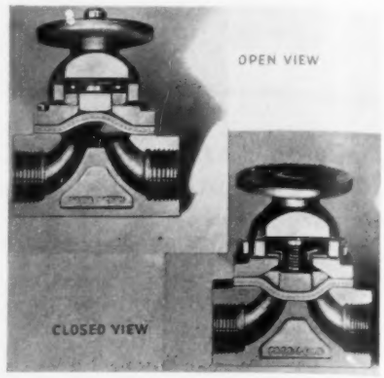
Attached to the second hand rotor is a permanent horse-shoe magnet which creates a new rotating field in 118 iron teeth driving still another ring with 120 teeth at the rate of one revolution per hour. This runs the minute hand. Attached to the minute hand rotor is a second permanent magnet creating a rotating field in 22 teeth and driving a 24-tooth rotor one revolution every 12 hours for the hour hand.

The entire operation may be explained by saying that each rotor travels only two teeth for each revolution of its magnetic field. By changing the number of teeth, any desired speed may be obtained.

New Packingless Valve

Hills-McCanna Co.

AS THE illustrations show, this valve has no stem packing or stuffing boxes. A diaphragm, operated from the side not exposed to the flow, controls the passage of fluid through the valve. The diaphragm, therefore, protects all working parts from the substances handled. For corrosive liquids and those containing gritty solids in suspension this is a considerable advantage. Moreover, access to the body of the valve does not necessitate removal from the line. An incidental commercial feature is that corrosion resisting valves of this type are priced in the range of iron valves, because the design requires only the body to be cast in special corrosion resisting metals.



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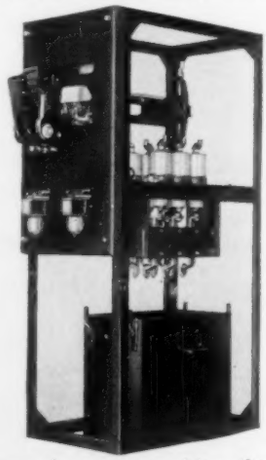
High Voltage Motor Starter

Allen Bradley Co.

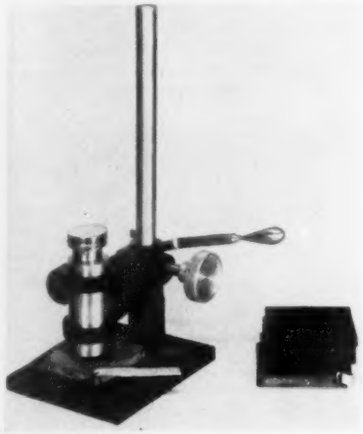
OPERATING as a starter for 2500 volt squirrel cage induction motors, this starting switch throws the motor directly across the line. A pilot device operates a 2-pole relay which in turn causes the oil switch to close. Overload protection is immediately effective through current transformers in two primary phases, the secondary currents of these transformers energizing the magnetic coils of 2-overload relays. The motor is disconnected from the line by opening the contacts of any pilot device in the controlling circuit of the 2-pole relay. No-voltage protection is provided by the automatic opening of the 2-pole relay when voltage fails, which in turn disconnects the motor.

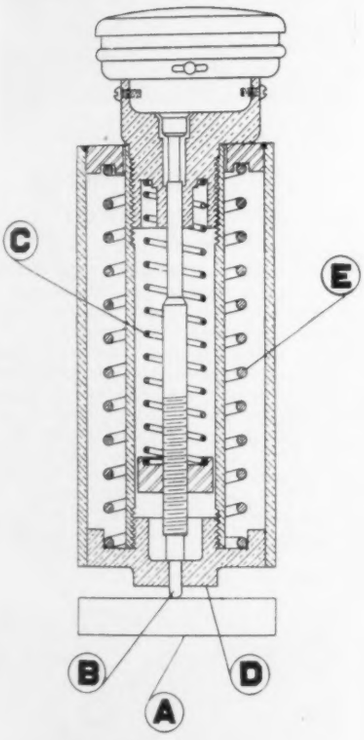


Firestone Penetrometer

American Instrument Company

REFERRING to the cross-sectional drawing: "A," the material to be tested, is placed on the base of the instrument directly under the penetrating point, "B." As the mechanism is lowered by depressing the handle the penetrating point comes in contact with the material, "A," and depresses it to a depth depending upon the resistance which the material offers to distortion.





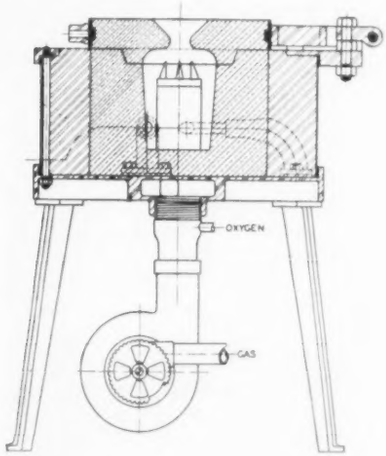
The top of the needle "B" is in contact with the spindle of the dial indicator so that any upward movement of the needle is registered on the dial. The dial gage reading therefore indicates the material's resistance to penetration. It will also be noted that the upward motion of the needle is resisted by a spring, "C." By carefully conducted tests it has been determined that, for the ordinary run of commercial rubber, this spring should exert a pressure of three pounds.

P. C. E. Furnace

The Denver Fire Clay Company

THE SOFTENING point of clays and other materials used in the manufacture of refractories is of great importance. The Pyrometer Cone Equivalent of most ingredients is far above the temperature obtainable in ordinary laboratory furnaces. Pot furnaces of the common design fail to meet the American Society for Testing Materials requirements of the P. C. E. test, aside from their inability to reach the necessary temperature.

This furnace was developed at the Mellon Institute by Mr. Vance Cartwright and Mr. Stuart M. Phelps as a result of request from the refractories industry for a portable, efficient furnace capable of reaching high temperature for evaluating clays. It is designed to burn either artificial or natural gas, or propane, which can be purchased in 50 or 100 lbs. cylinders. Cone 34 can be brought down with these fuels and, by the introduction of a small amount of oxygen, temperatures as high as cone 39 can be obtained.



The furnace in its final design is shown in sectional view on this page. Burners are cast from high temperature alloy which withstands temperatures up to 2010° F. Four burners are arranged tangentially on a cast manifold to assure uniform distribution of the fuel to each burner.

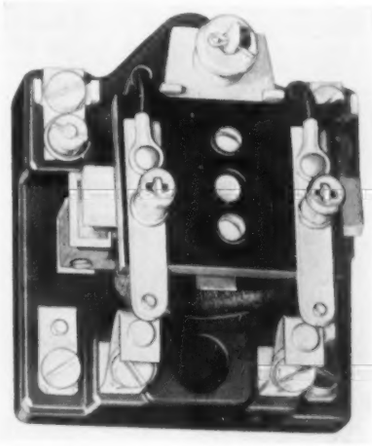
The air-gas mixture is supplied by a direct driven electric motor blower mounted with vertical outlet directly under the center of the furnace. The speed of the blower is controlled by rheostat conveniently mounted on the furnace. The blower also is provided with a shutter box that makes it possible to adjust the volume of air from 200 to 4500 cu. ft. per hour at a pressure of 5 in. of water. The gas passes through the blower, assuring perfect mixture of fuel. Provision is made for the introduction of oxygen.

The refractory cover recesses into the furnace body and is carried in an iron band hinged in such a way that the cover must be lifted before it can be turned to one side. The inside of the cover is designed to direct heat by radiation to the cone pat. A vent hole in the center affords a good view of all cones while the furnace is in operation.

A. C. Magnetic Contactor

Square D Company

THESE contactors are built in a variety of combinations for various electrical controls of temperature, time, lights and small motors. The range of ratings is from 3 to 15 amperes for non-



inductive load or for fractional h. p. sizes of 110 volt single phase motors.

Structural features of these contactors are: laminated magnet frames, floating armatures, silver to silver contacts, and porcelain bases.

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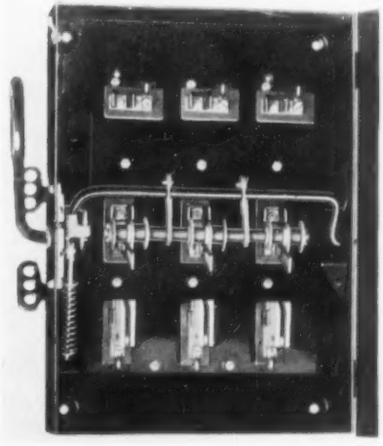
Safety Switch

Square D Company

THIS switch is an improved form of the Square D Type A safety switch. The interlock mechanism of the switch has been greatly simplified with fewer operating parts and is more compact, giving ample wiring space on both

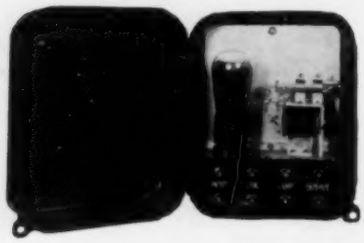


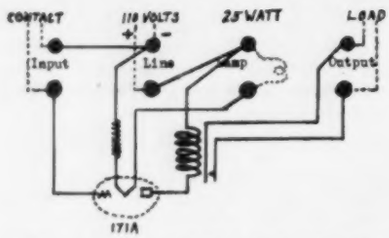
sides of the switch, as well as at the top and bottom. The interlock is controlled by a key, but it may be disabled with a screwdriver slipped into the slot for operation of the switch when the door is open. The door can only be opened when the switch is closed through the use of the key.

Very Sensitive Relay

C. F. Burgess Laboratories, Inc.

THE MICRO-RELAY, as this relay is called, consists of an electronic tube in the plate circuit of which is a normally closed mechanical relay, said relay being held open by the residual value of plate current with an unbiased grid. The controlling contacts are so wired that when they come into contact a negative bias is placed on the grid, immediately causing the relay to close. This action occurs even with extremely high contact resistance in the order of 20 megohms; in fact, the relay will function with any contact resistance appreciably less than the insulation between the electrodes of the tube.





The components of this electronic relay are mounted in a stout metal cabinet measuring 7x8½x4¼ inches. A terminal strip inside the cabinet provides for connections with the external circuits. Knockouts permit of permanent wiring using BX or conduit. The relay is arranged to operate with a standard 25-watt lamp wired in series with the filament of the tube. This lamp serves the triple purpose of a resistor, pilot light to indicate that the relay is operative, and illuminator for the indicating instrument, to which it is attached.

The mechanical relay of the unit is provided with a vacuum contact in place of the usual exposed contact points. This feature permits the handling of currents up to 6 amperes at 220 volts. In addition, the relay may safely be used in explosive atmospheres, since the contact is totally enclosed and no danger of ignition exists.

The delicate controlling current required to actuate the micro relay must result in successful applications in equipment, which might operate only temporarily without it. The infinitesimal current is reduced to the point where oxidation, arcing and similar undesirable and indeed deleterious phenomena are eliminated. As an example of this point, the useful life of a contacting mercury thermometer may be increased indefinitely, since the current passing through the mercury-to-electrode contact is so small that contamination of the mercury in the thermometer stem cannot take place.

This micro relay is available in several models for different applications, such as normally open or normally closed, 110-volt or 220-volt, a. c. or d. c., and normal operation or time delayed operation. It may be operated as rapidly as 120 times per minute, being limited in speed by the inter-electrode capacity of the tube. A time lag of approximately ½ second exists because of this capacity effect, and provides the distinct advantage of preventing chattering when the relay is actuated by a delicate contact device, which in itself may have a tendency to cause chattering. The time lag of the micro-relay may be increased by means of a simple control incorporated in the assembly, the turning of a knob one way or the other increasing or decreasing the time lag to meet specific requirements.

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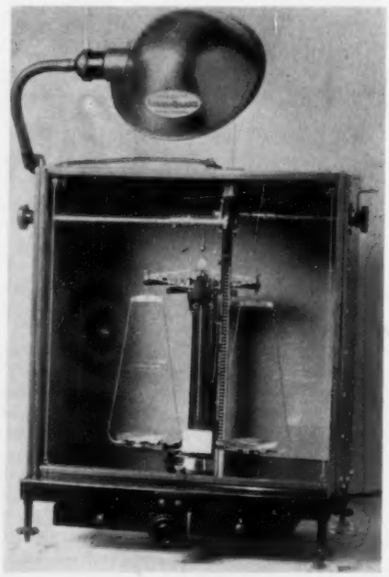
Chain-Poise Variable-Weight Balance

The Heusser Instrument Mfg. Co.

IN THE illustrated balance the problem of weighing small loads with a large weight is accomplished by means of a variable-weight in the form of a chain weight suspended from an auxiliary arm attached to the balance beam. The novel feature in this construction is the ability of using the chain weight for two purposes, namely: (1) That of poising the swinging system; and (2) that of weighing all or part of the load. From this twofold purpose the balance derives its name: "chain-poise variable-weight balance."



Poising the swinging system (beam and hangers) is accomplished quickly by either adding or subtracting (as the case may be) a portion of the chain weight. This is done by turning the knob at the right side of the balance and adjusting the zero line of the divided weight scale with the indicator line, which is done by raising or lowering (as the case may be) the divided weight scale by turning the knob at the left side of the casing.

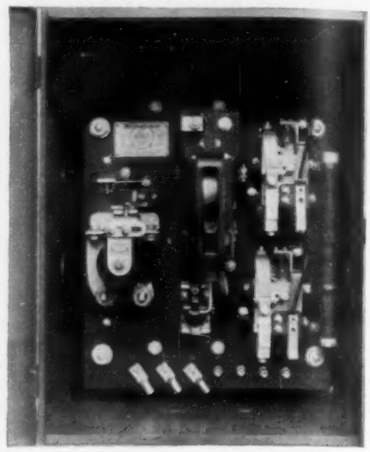
This chain-poise variable-weight principle is applicable to all types of analytical balances, micro-chemical balances, and assay balances. Also, it is claimed to reduce possible small errors of the mechanism by the ratio of auxilliary arm length to length of the balance lever.

Magnetic Motor Control

Westinghouse Elec. & Mfg. Co.

DESIGNED especially for mining service, these magnetic starters for d.c. motors are enclosed in a rolled steel cylindrical case. Controller starts and brings motor up to full speed in a predetermined length of time with any load the motor is capable of starting and accelerating.

Overload protection is provided which will permit high starting or high momentary peak loads and at the same time trip instantaneously in case the starting load or peak load exceeds the commutating limit of the motor. In addition to the above features the same overload relay protects the motor from overheating on moderate continuous overloads.



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Refractory Protected Mercury Switch

Westinghouse Lamp Co.

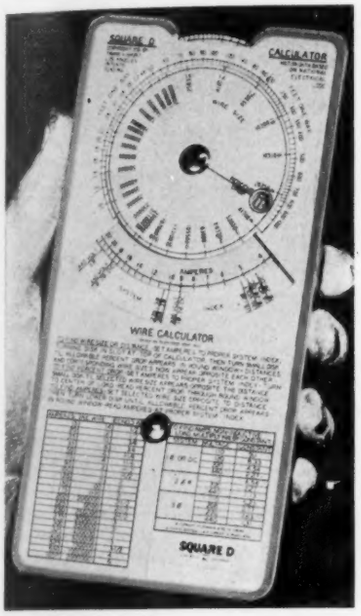
TO PROTECT the glass walls of this switch a refractory block is placed within the switch, providing a chamber to confine the arc caused by the opening and closing of circuits having surge characteristics. The refractory protecting chamber is so designed as to insure a dependable impact contact between two pools of chemically pure mercury. The ease with which this switch may be mounted and connected, together with the comparatively small amount of energy necessary to operate it, make it particularly suited for use with such devices as temperature regulators, motor controls, etc.

Calculator for Wiring and Motor Data

Square D Company

THIS new wiring and motor data calculator is of particular interest to inspectors, electrical engineers, contractors, estimators, wire-men, etc.

This device is compact in size, 7" long, by 3½" wide by ¼" thick. It comprises two calculators really, one for computing wiring data and the other for computing motor data.



The wiring calculator for interior and conduit wiring problems will figure any one of these four items—amperes, feet of wire, size of wire, and percent drop. The dials are easily set and the reading is automatically given.

The motor calculator gives data on the three principal types of 220 volt and 440 volt 3 phase motors. Each type is represented by a colored section of disc. Using the proper disc segment, set for horsepower, the following data can be read—circuit switch, starting fuse, conduit size, wire size, necessary running protection and full load amperes.

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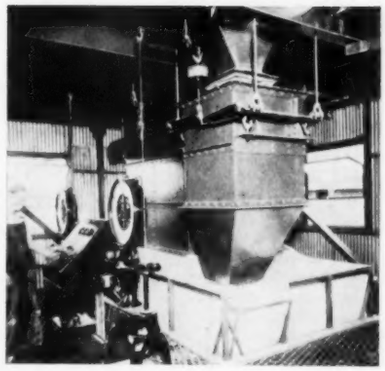
Photo-Electric Weighing Control

General Electric Co.

DESIGNED for the automatic proportioning of concrete aggregates, this device consists of a photoelectric tube mounted inside the indicating mechanism housing of a dial scale and located immediately behind a narrow slot in the dial. On the outside of the housing is attached an electric lamp and reflector. A slot is between the light-sensitive tube and the electric lamp or light source. When any object is brought between the electric lamp and the slot in front of the photoelectric tube, a change in current is produced in the tube and this is utilized to actuate an electrical relay. The light "interceptor" with a paddle-like tip, is attached to the regular indicator so that when the dial or weight indicator is at the zero desired weight



position, the interceptor is over the dial slot to cut off the light from the electric lamp to prevent its reaching the photoelectric tube. When the dial indicator is in any other position than zero, the slot is uncovered and the light rays from the electric lamp are transmitted through the slot to the light-sensitive tube inside the mechanism housing.

If it is desirable to weigh out one thousand pounds of one of the materials going into the batch, the poise of the beam assigned to that material is moved out to the one thousand pound graduation on the beam. When the poise is moved out for the material to be weighed, the indicator revolves in a counter-clockwise direction and indicates an amount equal to the value of the poise setting. The operator starts the feed of the material by means of a starting button and, as the material accumulates in the weight hopper, the indicator hand moves in a clockwise direction until it reaches zero, at which position the interceptor affects the photoelectric tube which in turn energizes the relay, shutting off the flow of material.

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Water and Dust Tight Control Station

Square D Company

THIS momentary type control station of water and dust tight construction is designed for application in packing plants, creameries, flour mills, and similar locations where extreme moisture and dust conditions are encountered. It consists of a push button in a cast iron enclosure which is gasketed to exclude water and dust, and is available in three designs: one marked "Start" and "Stop," one marked "Start" only, and one marked "Stop" only.

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Portable Potentiometer

Gray Instrument Co.

WITH a view to making a potentiometer suited in every way to being portable, this self-contained instrument has been designed. It is complete with standard cell, battery

for potentiometer circuit, regulating rheostats, galvanometer, volt box for 750 volts, and a standard low resistance for 150 volts.

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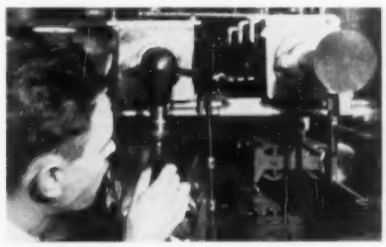
Lamp to Measure Furnace Temperatures

General Electric Co.

THIS new pyrometer lamp consists of a black-coated, pear-shaped bulb containing an inverted U-shaped carbon filament and a small eyelet about ⅛ in. apart. These are mounted midway between two windows in the bulb and in such a manner that the center of the eyelet and horizontal portion of the filament are on a line of sight between the centers of the windows.



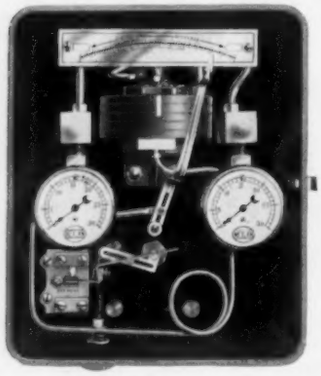
When measuring the temperature of a furnace, the lamp is held as near the furnace door as convenient and the part to be measured is viewed through the windows of the bulb. The brightness of the filament is adjusted by varying the current through it by means of a rheostat until it matches that of the furnace at which time the filament current is read on an ammeter. The temperature corresponding to this current value is read from a calibration chart.

The advantage of the eyelet is that it indicates the calibrated portion of the filament and enables the operator to keep his eye focused on the plane of the filament at the time it blends with the background.

Non-Recording Flow Controller

Neilan Co., Ltd.

THIS instrument is a flow control instrument of the non-recording variety. The device operates on only the slight amount of force required to operate the fully balanced Neilan compound pilot valve. This force is supplied by the differential pressure acting through stainless steel mercury pots. The device is also equipped with a safety elbow which protects the instrument in the event that the differential exceeds the range of the instrument.



A feature of this device is that it can be easily converted from one differential range to another. Furthermore it can be easily set from the outside of the case by simply turning a knurled thumb nut. The instrument operates any size diaphragm control valves from ⅛-in. in size on up. Working parts are machined of Nirosta KA2 stainless steel. The operating mechanism is enclosed in a light, strong Duralumin case which is corrosion-resistant.

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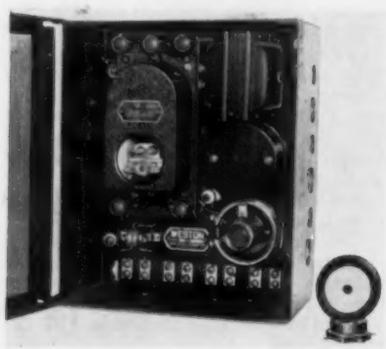
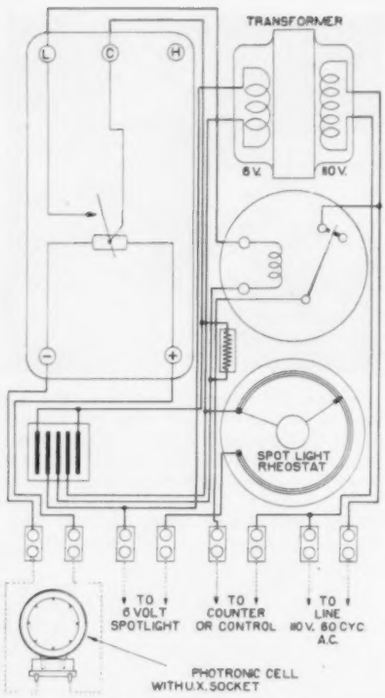
Photoelectric Relay

Weston Electrical Instrument Corp.

INTENDED for smoke detection, counting, or other industrial control of process or production, this relay claims the distinctive feature of not requiring the use of an amplifier.

The equipment consists of a light source, a Photronic cell with mounting base, and a relay cabinet containing the necessary relays for controlling circuits of either 100 or 1000 watts at 110 volts. The power relay for 1000 watts may be made multi contact with interlocking or lock-in circuit arrangements.





The light source is of the spot-light type employing a 21 candle power 6 volt automobile headlight bulb. This can be replaced by a 32 or 50 candle power bulb if a more powerful beam is required. It has a focusing adjustment for concentrating the light on the Photronic Cell.

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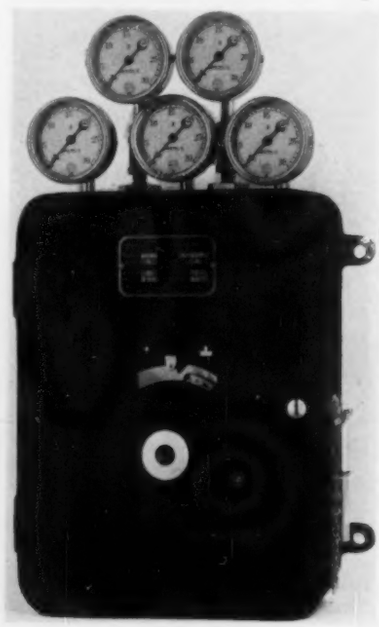
Process Cycle Controller

The Bristol Company

DESIGN of this company's earlier single-cam process controller has been advanced to provide four and six-cam controllers. It is consequently possible to provide complete automatic control of a process which has as many as 6 independent operations and in which the various operations are overlapping or intermittent throughout the cycle. It is further possible to combine more than one of these instruments for a process and thus increase the number of operations which can be controlled to 8, or 12, or more.

Where it is desired to change the duration of the cycle, as for example in producing different grades of a product by the same process, a two speed controller is provided (illustrated). This device can be adjusted by properly setting a calibrated dial.

These instruments find application in all process industries, particularly the food and rubber industries. Coordinated with suitable control functioning equipment, they regulate, to the desired sequence and duration, temperature, pressure, flow, etc.



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New A.C. and D.C. Drum Controllers

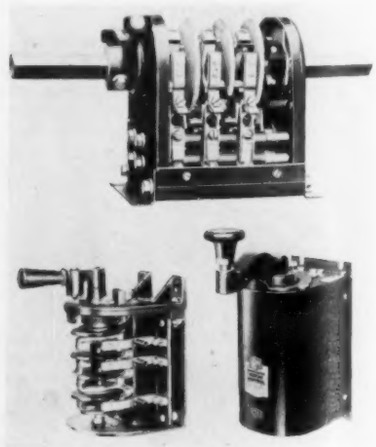
Cutler-Hammer, Inc.

THIS new line of a.c. and d.c. across-the-line type reversing drum controllers are designed for monorail hoists, auxiliary machine tool motors and for miscellaneous applications. They are made in two or three pole types; with radial or rope lever operating mechanism; self-centering or non-self-centering mechanism; and with or without either main line limit switch protection or pilot circuit interlocks.

Construction features include: small and compact design; light weight, easily removed, non-stubbing contact fingers; slot type mounting holes; easy to change from self-centering to non-self-centering; and shaft extension of six inches beyond both ends of drum when rope lever drive is furnished.

The types which have pilot circuit interlocks can be used as a reversing switch in conjunction with a separate automatic starter or as a magnetic contactor to provide limit switch selection in either direction or magnetic main line feature.

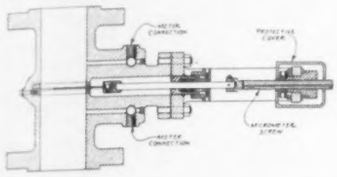
The illustration shows: At top, type X, 3 pole, with rope lever, without interlocks; at left, type V3, 3 pole, with radial lever, without interlocks; at right, type XP, 3 pole, with radial lever, with pilot circuit interlocks.

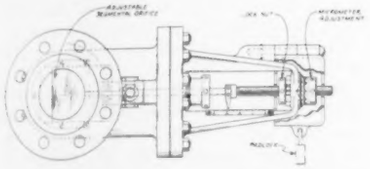


Adjustable Orifice

Bailey Meter Company

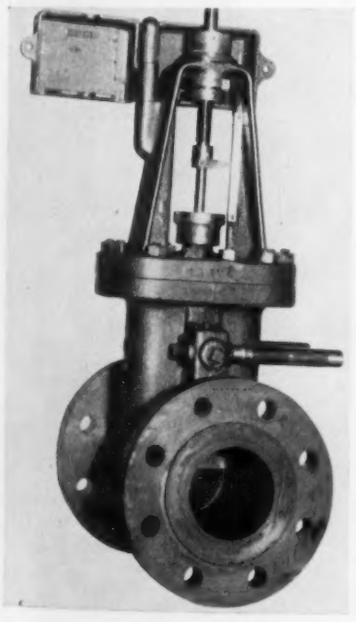
FOR fluid meter installations where it is desirable to obtain accurate measurements over a wide range of capacity, this adjustable orifice has been developed. It is particularly suitable for use with meters measuring gas or low pressure heating steam, since on these services the desired capacity is often dependent upon the season.





As illustrated by the figure the adjustable orifice consists of a flanged body with integral meter connection. It can be readily installed in a steam, water or gas line and connected to any differential head type of fluid meter. The adjustable orifice functions similarly to the commonly-used fixed type of Bailey segmental orifice. A micrometer adjusting screw permits setting the height of the gate segment within .001 inch. When it is advisable to change the capacity of the meter, it is simply necessary to set the micrometer screw at the reading corresponding to the desired maximum capacity, as obtained from curve sheets furnished with the orifice.

The adjustable orifice permits changing the maximum capacity of the meter as much as 40 to 1 and consequently is equivalent to a multitude of fixed orifices. The change may be made in a few minutes' time without disrupting meter operation or diverting the flow through a bypass line.

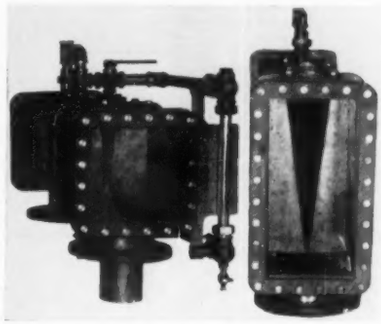


Weir Meters

Vulcan Copper & Supply Co.

THE FLOW of liquids to and from distillation and similar equipment is measured readily with visual weirs and orifice meters. While these liquid streams are usually under atmospheric pressure at the point of measurement, with proper venting arrangements for connection to the air or vapor space of the liquid processing equipment, the V notch meter shown may be used with either pressure or vacuum. This line of V-notch meters, in two body sizes, are furnished with readily interchangeable plates. The smaller size body takes plates having maximum capacities of 200, to 2,000 gallons per hour, while the larger size has standard plates with maximum capacities of 2,000 to 5,000 gallons per hour.

The body consists of a long box or calming section designed to allow the liquid to present a mirror smooth surface before flowing through the weir. In front of the weir plate is a section with glass plate and discharge pipe. The V-notch is accurately machined in a quarter inch plate to a knife edge, and machine graduated on both sides to permit accurate reading. An external gage glass with scale facilitates the reading of liquid level.



These meters are furnished regularly in copper, bronze or aluminum and are also available in other corrosion resistant materials. Each weir is individually calibrated at from 20 to 30 points, and the calibration chart is supplied with the meter.

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Precision Pressure Controller

Mason Regulator Co.

PRINCIPAL feature claimed for this new pressure regulator is that it affords a straight line control function. That is, for every increment of movement of the control element there is a definite and uniform increment of movement of the diaphragm control valve.

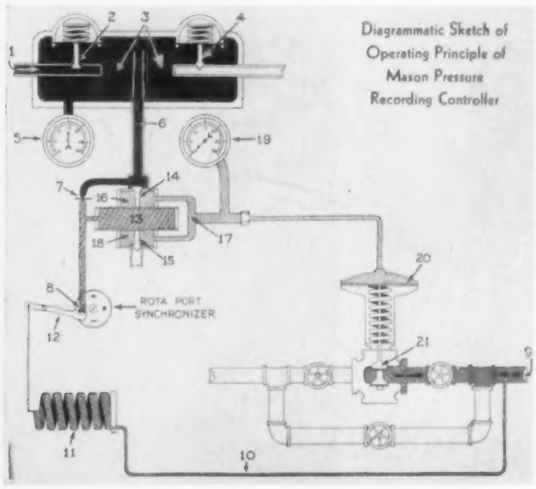
One of the novel improvements in this controller is a device which makes the control readily adjustable to any particular process. This device, called a rotaport synchronizer, can be quickly turned to give any desired degree of control sensitivity.

The operating principle in the case where a constant back pressure is to be maintained, can be followed from the diagram.

The operating air or gas supply from (1) passes through reducing valve (2) (which is set for 15 lbs.) into reservoir (3). If the pressure in (3) tends to exceed 15 lbs., safety relief valve (4) opens and permits the excess pressure to escape. Pressure in (3) passes down pipe (6) through a fixed orifice (7) and out through orifice (8).

The back pressure (9) which is being controlled is transmitted through (10) into helical tube (11). As this back pressure increases it tends to unwind (11); this in turn moves the "cleaver" type arm (12) across orifice (8). As (12) gradually closes (8) to position shown by the dotted cleaver arm, this causes the pressure in (13) to build up, since a constant amount of air or gas is being supplied through (7).

Increasing pressure in (13) forces valve (15) closed; and valve (14) open, allowing pressure from (6) to enter chamber (16), flow through (17) and equalize the pressure in (16) and (18). As soon as the pressure in (16) balances pressure in (13), valve (14) closes and prevents pressure in (16) increasing any more. This same pressure in (17) is indicated by gage (19) and exerts a downward force on control valve diaphragm (20). This force opens valve (21) and permits the excess pressure in (9) to escape the control valve.



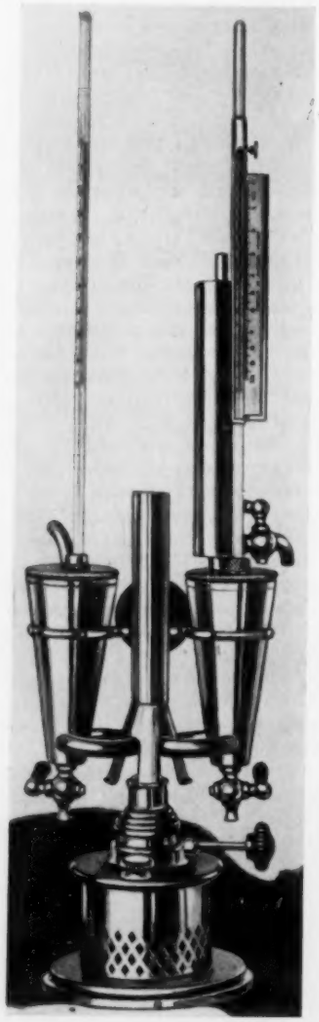
When the back pressure in (9) decreases, the helical tube (11) contracts. This moves arm (12) so as to open orifice (8). Pressure in (13) now partially bleeds out, permitting the pressure in (18) to overbalance (13) and open valve (15) which allows the pressure in (17), that actuates diaphragm (20), to drop until it again balances the pressure in (13). This causes valve plug (21) to close or partially close again. This operating cycle is continuous so as to maintain either an exact back pressure or reduced pressure as required.

Direct-Reading Ebulliometer

C. J. Tagliabue Mfg. Co.

THIS instrument gives a direct reading of the alcohol content of a liquid, without reference to charts or tables. The principle, based on the change of boiling point with the change in alcoholic content, is old. The distinctive novelty of this device is that both the water and the liquid under test are subjected to boiling point temperatures simultaneously.

This eliminates duplication of operations in boiling both liquids separately. But far more important is that, by taking both boiling points simultaneously, no corrections need be applied to the readings, because any variation in temperature or pressure affects both liquids alike.

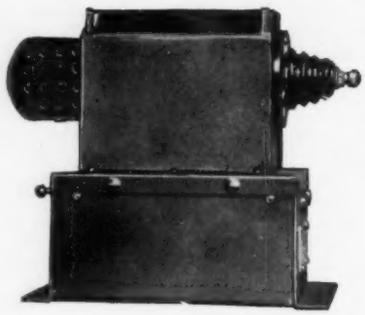


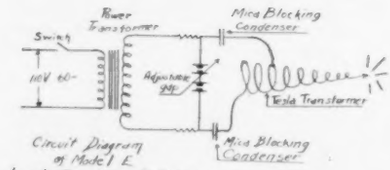
In operation a movable scale on the test-liquid thermometer is clamped with its zero at the boiling point of the water, as read from the water thermometer. The reading on the sliding scale from zero to the mark which comes alongside the top of the mercury in the test liquid thermometer is the value of the test liquid's alcoholic content.

Gas Leak Tester for Vacuum Tubes

Lepel High Frequency Laboratories

TO DETECT gas leaks in vacuum tubes and incandescent lamp bulbs, the gas in the bulb is excited into glowing by radio frequency currents. This tester is a quenched gap type generator of such currents, or short wave electrical oscillations.





Circuit Diagram of Model E Lepel Short Wave Oscillator

It consists of a 60 cycle step-up transformer, two common lever adjustable tungsten gaps, two mica condensers, a high frequency transformer, and the necessary switching and housing mechanism.

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Telescope Mounting

Baldwin Southwark Corp.

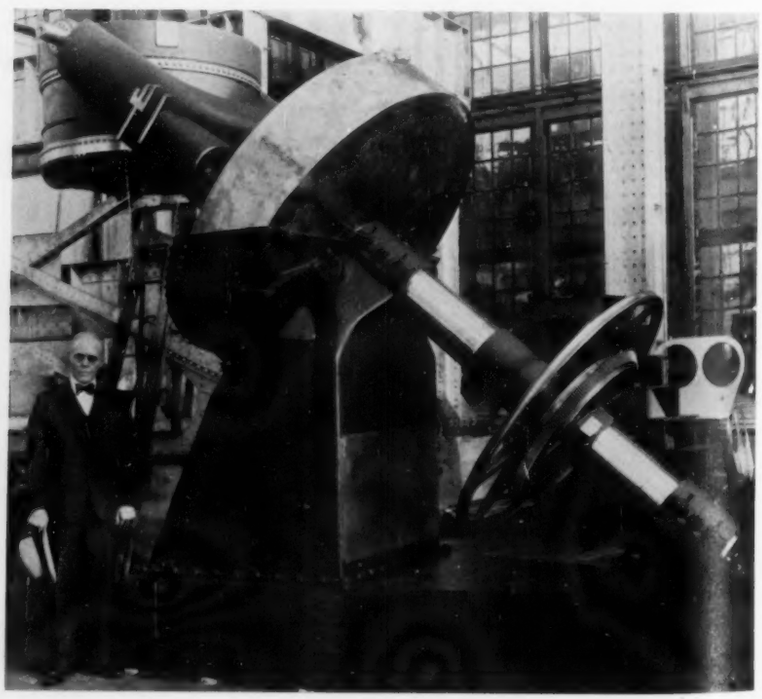
THE TELESCOPE mounting shown below is an excellent illustration of the fine machine work possible in the manufacture of even huge-sized instruments.

The accuracy attained in the manufacture of this telescope mounting may well be illustrated by certain final measurements which were made when the assembly was completed. The shaft shown was mounted in the bearings and rotated. A measurement was taken with an indicator head having graduations of 1/10,000 in. Repeated measurements indicated that the eccentricity of this polar axis did not exceed a quarter of one of these divisions. The angle of the polar axis with the finished face of the base casting was accurate to specifications within less than 10 seconds of arc—the limit of sensitivity of the measuring device. The allowed tolerance was 30 seconds of arc.

The alignment of such parts as the shell tube, mirror support plate and trunnion ring had to be completed with an accuracy so great that the motion of the telescope during operation would not cause a movement of the image.

There are novel features in connection with the telescope itself which are of great interest. This telescope, of the Ritchey Chretien reflecting type, was built for the Naval Observatory. It has two optical mirrors, both of silvered glass. The large mirror, of 40 in. aperture, is concave, the small mirror, of 16 in. aperture, is convex. The combination of the two mirrors gives a focal length of the telescope of 22 ft. 8 in. Both mirrors are being made of low-expansion glass (similar to "Pyrex"), designed by the celebrated Saint Gobain Glass Company, of Paris.

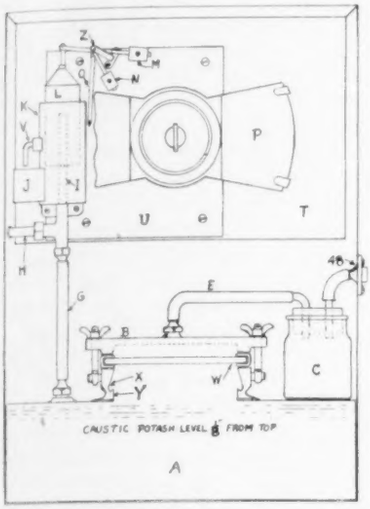
This telescope is designed primarily for celestial photography, but is suitable, also, for the finest visual and spectroscopic observations.

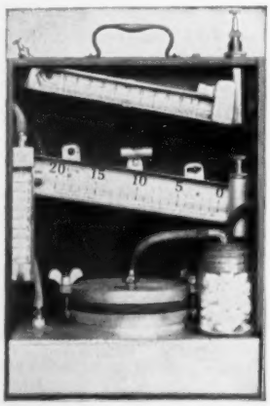


Portable CO_2 Meters

Defender Automatic Regulator Co.

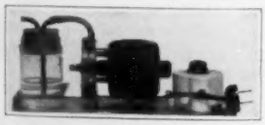
THESE instruments are provided in both indicating and recording forms. A feature emphasized about these CO_2 meters is that a motor is used only to pump the gas under test into the meter, there being no motor involved in the operation of the meter.



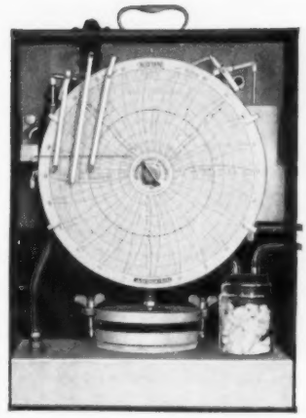


The principle of operation, which, it is claimed makes the instrument free from variations in the flow of the gas to be tested, follows: Inlet gas is drawn from the boiler by a separate unit and forced into the analyzing part of the recorder at (48) to pass down through bottle C which is filled with dry lump calcium chloride. This absorbs the moisture out of the gas which then flows through pipe E into the chamber below plate B and passes out through a rear hole in the plate and escapes.

As the gas passes over the porous plate W a portion of its diffuses through into chamber A, where its CO_2 content



is absorbed by the liquid KOH (caustic potash) in that chamber. This creates a partial vacuum above the liquid KOH level in chamber A, which causes the inverted sealed bell float L to change its level in tank K, moving pen arm O.



The bell float L is suspended on two needle point bearings Z and the float is balanced with weight M while all adjustments for making the pen arm read higher or lower are made with the pendulum weight N. This is for calibrating the instrument to read directly in CO_2 content and this adjustment must be made by using a hand Orsat to test the flue gas while the unit is in operation.

The circular groove X which is machined on the inside of the steel top Y is for filling with white parafine so as to prevent the KOH from creeping up and getting on the porous plate W.

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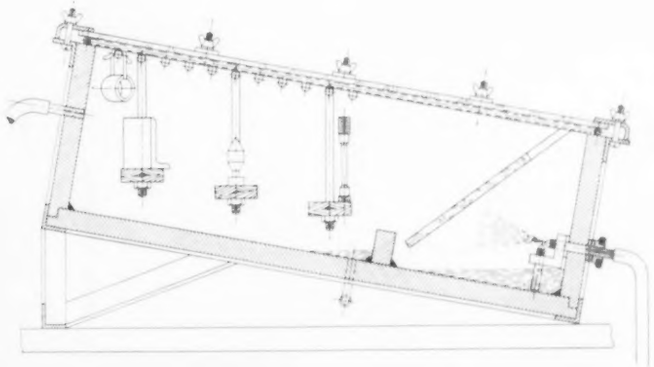
Salt Spray Corrosion-Test Chamber

American Instrument Co., Inc.

DIFFERENT heats of the same corrosion-resisting metal supplied to the Navy have been found to vary greatly in their ability to withstand corrosion. The requirement has therefore been made that all material of this kind pass a specified salt-spray test before acceptance.

The test requires exposing a prepared specimen of the material in the test chamber illustrated here to a salt-spray at no more than 5 lbs./sq. in. pressure, using a 4% sea-salt solution for 100 continuous hours.

The box is thoroughly water-proofed inside and outside with two coats of asphaltum paint. The cover of the box consists of a plate of ⅜-in. thick transparent glass held down securely on a soft rubber gasket by 12 clamps which are tightened down with thumb screws. Inside the chamber is a 5/16-in. thick glass baffle which prevents the spray from striking directly onto the test specimens. Notches are cut in the side of the box for the purpose of permitting rods to be set in place from which test specimens may be suspended. Two wooden shelves which have been boiled in paraffine are supplied with the box to hold shapes which may not be suspended conveniently.



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Explosion-Proof Motor Starter

The Electric Controller & Mfg. Co.

ESSENTIALLY this starter is an oil-immersed across-the-line switch operated through relays by a distant push-button, and enclosed in an explosion-proof case. It is designed for controlling a. c. standard squirrel cage motors up to 10 h. p., or double squirrel cage types up to 20 h. p. The parts are all mounted on a slate chassis, which is easily removable from the tank. For low-voltage, either automatic release or automatic protection can be provided. Automatic over-load protection is provided by the breaking of the switch-coil circuit when a wire over-load element lengthens due to heating. The overload device therefore operates on low prolonged overloads or in large, quick overloads.

Improved Push Button

Lincoln Electric Co.

A FEATURE of this push button switch, which is an improved model of this company's earlier one, is that the start button is inside of the stop button, as shown in the accompanying photograph. The stop button can be operated from any angle by merely striking the front of the control box with the flat of the hand, but the start button must be operated with the finger. With the new push button, the stop button can be locked in the off position by pushing it in and twisting it to the right. Heavy springs prevent accidental operation of either button when not locked.

It is claimed the button will handle the heaviest control circuits up to 600 volts a.c. or d.c. because the contact opening is larger than usual. This is because the contacts use extra heavy double break solid copper contacts which have a positive wiping action. Contacts are enclosed in a dustproof, cold moulded asbestos case.

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Direct Reading Illuminometer

Weston Electrical Instrument Corp.

WITH this new instrument, one reads illumination intensities with the same ease and facility as reading ammeters and voltmeters. It consists of an indicating instrument and a light target assembled in a portable case. The light target is on the end of a flexible cord so that it may be placed in any position. This light target or searching unit has two Photronic Cell units which convert light energy directly into electrical energy without the use of batteries or other auxiliary voltage. It is claimed they maintain constant output over long periods of time and there is no dark current. The output from the Photronic Cell units is considerable, allowing the use of a rugged portable instrument calibrated directly in foot-candles.

There are three ranges on the instrument, namely 10, 50 and 250 foot-candles. A range changing switch is provided for the selection of the desired scale. Other combinations of ranges are being added to the line and will be available shortly. The light target may be placed at a distance from the observer so that shadows and lights reflecting from light clothing will not cause errors in readings. Light may be read from all angles and the light target may be placed in relatively inaccessible places, in show cases, windows, etc. The absorption of light by painted walls, screens, etc., can be measured directly by turning the light target so that it faces the surface.

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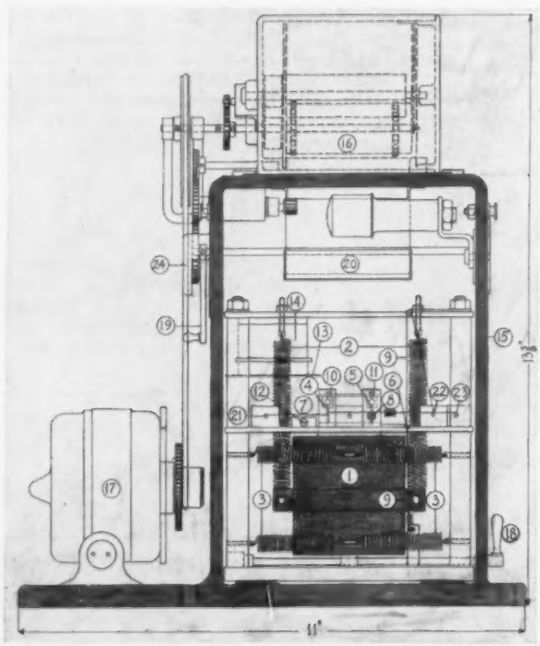

Tri-Dimensional Vibrograph

Vibration Specialty Co.

THE Vibrograph is a form of seismograph which indicates and records components of vibration simultaneously in a vertical and two horizontal directions. The instrument comprises a heavy cubic mass suspended in a frame by a system of springs and means for indicating and recording relative motion between the mass and the frame. When placed upon any vibrating body the frame vibrates with the body while the mass due to its inertia tends to remain at rest.

Relative motions between the suspended mass and the frame result in the rotation of three spindles (4), (5) and (6) which carry mirrors which reflect images of a lamp filament upon a screen or photographic film. The light beam from each mirror therefore traces on the film a curve of one component of vibration.

To secure a timing record on the film a fourth mirror (12) is mounted stationary on the frame in such a manner that the light is reflected to the photographic film. A slotted disc (13) driven by a small synchronous motor (14) intermittently intercepts this light so that a record is made at intervals of 1/2000 of a minute. Thus a timing record is made in the form of a succession of small dots alongside of the record of vibrations.

Many and varied uses of the vibrograph suggest themselves. In the powerhouse, for instance, the magnitude and character of vibration during starting or while changing load may be determined and recorded.

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4-Way Valves

Vickers, Inc.

THESE 4-way valves for machine tools and other hydraulically operated equipment have as a distinctive feature operation by hydraulic balance. This is claimed to make it impossible for them to bind due to pressure, and to assure more sensitive operation. There are three types of these 4-way valves:

A latch controlled valve, which makes one complete cycle and then stops; it is particularly adapted to press operations, hydraulically operated furnace installations, etc. Operator manually starts machine in one direction; at end of stroke a stop trips latch and allows internal spring to shift valve to reverse position. When end of return is reached, machine is stopped by the valve.

A pilot operated 4-way valve, with manual and mechanical pilot valves which provides remote control without the use of levers, links, etc., and can be placed out of sight or wherever most convenient. It has simple external adjustments for controlling reversing speed—this feature is used to eliminate shock from rapidly moving tables.

The third 4-way valve is manually operated. These valves are provided for pressures up to 2000 lbs./in.^{2}

INSTRUMENTS ABSTRACTS

Abstracts on instruments and devices for measurement, inspection and control.

INSTRUMENTS ABSTRACTS, incorporated in INSTRUMENTS, is the most complete review on the subjects of measurement and control.

Abstractors cover over 500 domestic and foreign publications.

Upon receipt of the abstracts they are checked against permanent files to avoid duplication and after being rewritten to conform to our style they are classified.

Oftentimes an abstract can fit under two or even more sections. In that case we decide who will be most interested in the article, and include it under that field of reader interest. It is our aim to so arrange the abstracts that a person interested, for example, in viscosity, will keep in touch with all the important articles in his field if he reads only section 2.10. For instance, an article on "Vacuum Tube Means of Measuring Viscosity" appears under 2.10—under "Measurement and Control of Physical Properties—viscosity," although it would also fit under section (5.4)—"Electronic Devices and their Applications."

An improvement we hope to make in the Abstracts Section in the near future is the cross-indexing of articles which fit under several sections. We suggest glancing through the whole Abstract Section. This takes but a short time, and the time so taken will be found very profitably spent.

The classification number at the end of each abstract will be of assistance in mounting them on file cards.

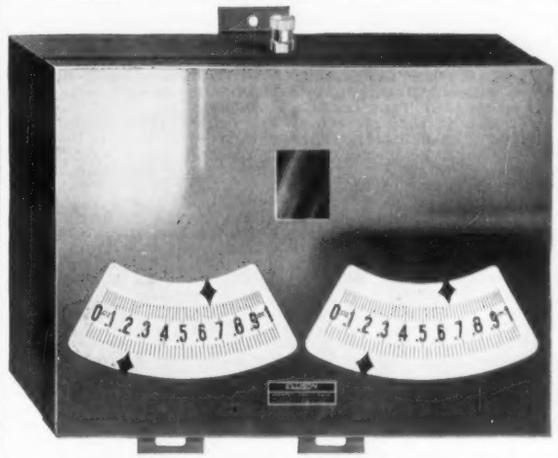
Negative print photostats of the original articles abstracted can be obtained at 35 cents per page plus 10 cents for mailing. The remittance should accompany the order.

CLASSIFICATIONS

(By Fields of Reader Interest)

MEASUREMENT TECHNOLOGY (1)
This section includes all matters concerning the art and science of measurement as follows:
Measurement Theory (1.1)
Under this heading will be included: definitions, precision of measurements, systems of units, and dimensional analysis.
Measurement Practice (1.2)
Covers Calibration and Standardization.
Calculation (1.3)
This does not include computation for instrument design, but covers calculations as a mode of measurement.
MEASUREMENT and CONTROL (2)
This section is devoted to those general measurement practices and control applications that are not confined to any one industry or branch of engineering. Thus temperature measurement and control, being of as much importance in chemical as in metallurgical processes, is a general field of interest to all industries and all branches of engineering.
Length, Angle, and Area, Including Surveying (2.01)
Time, Speed, and Acceleration (2.02)
Weight, Density, and Specific Gravity (2.03)
Pressure and Vacuum (2.04)
Flow and Volume (2.05)
Temperature (2.06)
Heat and Combustion (2.07)
Humidity and Moisture (2.08)
Power, Work, and Output (2.09)
Physical Properties, (Viscosity, hardness, elasticity, plasticity, surface tension, etc.) **(2.10)**
TESTING and INSPECTION (3)
Physical Testing and Inspection (including strength tests, bending, magnetic analysis, X-ray inspection, and other engineering test or inspection methods.) **(3.1)**
Production Testing and Inspection (This includes methods of testing and inspection for setting up production standards, grading, gaging, maintaining quality, etc.) **(3.2)**
Maintenance Testing and Inspection (Included here will be matters concerning standards and methods for controlling performance or service of equipment. Example—The problem of controlling long phone lines to give quality sound transmission would be included here.) **(3.3)**
ELECTRICITY and MAGNETISM (4)
Electrical Properties, Tests, Measurements, and Measuring Instruments (4.1)
Electrical Measuring Devices and Applications (4.2)
Magnetic Measurements (4.3)
Magnetic Properties, Materials, and their Applications (4.4)
ELECTRONICS and RADIO (5)
Radio Measurements (5.1)
Applications of Radio to Measurement and Control (5.2)
Photo-electric Measurements, Devices and Applications (including television) **(5.3)**
Electronic Measurements, Tubes, Devices, and their Applications (Under this heading would be included thermionic tubes, grid-glow tubes, thyratrons, neon discharge tubes, cathode-ray tubes, etc.) **(5.4)**
ACOUSTICS and VIBRATIONS (6)
Sound, Vibration, Phenomena and Measurements (6.1)
Sound and Vibration Devices or Applications (6.2)
LIGHT, OPTICS, and RAYS (7)
Light—General Measurements and Optical Applications (7.1)
Color Analysis, Color Matching (7.2)
Photometry (7.3)
Polarimetry (7.4)

(Continued on page A18)



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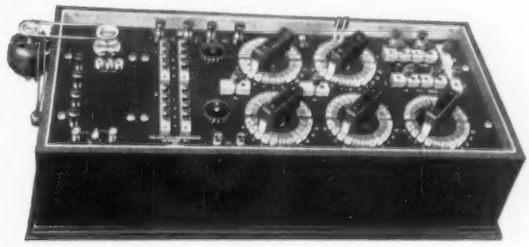

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MEASUREMENT & CONTROL (2)

Weight, Density & Specific Gravity (2.03)

The Direct Buoyancy Method and the Density of Molten Metals, Especially of Iron Alloys at Temperatures up to 1600° C. (Ueber die direkte Auftriebsemthode und die Dichte schmelzflüssiger Metalle, insbesondere von Eisenlegierungen bei Temperaturen bis 1600° C.) ERICH WIDAWSKI. *Doctor's Thesis. Published by Leo Voss, Leipzig,* 1930, 16 pages.

The density of materials, especially of metals in the liquid state, can be very exactly determined by measuring the buoyancy of another material, such as a ceramic body, in it. Certain precautions must be observed and the vessel containing the molten metal must be so arranged that it can be evacuated in order to eliminate errors by gases rising from the melt. The apparatus built for this investigation is described and the theory of the measurement briefly developed. Determinations have been made for tin, copper and copper-tin alloys, iron and steel in liquid state with a carbon content from 0.0 to 4.2% and, in addition, the cubic expansions of refractory materials are given. The volume of Fe-C alloys is found smaller than that computed from the law of mixtures which seems to point to the existence of a compound FeC_3 in the liquid state. Silicon increased the specific volume of liquid Fe-C alloys by 0.0010 cm.³/g. for a Si addition of 1%. Ha. (2.03)

New Norfolk and Western Railway Master Scale. *Scale Journal,* Vol. 18, Nov., 1931, pages 3, 4, 5, 9.

This scale is used to calibrate test weight cars, it has a capacity of 150,000 lbs. The construction is described in detail and tables given showing the materials used, the stresses set up in the different parts, and the chemical and physical properties of the materials. The applicable tolerances are 0.5 lb. up to 100 lbs. represented value, 2.0 lbs. up to 1,000 lbs., and 10 lbs. up to 10,000 lbs. Ha. (2.03)

Automatic Weighing Utilizes New Device. R. E. BEAR, *Electrical West,* Nov. 1, 1931, page 230.

Automatic weighing in the asphalt paving plant of the Standard Boiler and Steel Works, Los Angeles, is made possible by the use of the G. E. thrustor. This device combines the straight-line motion of a solenoid with the comparatively low inrush current and power requirements of a fractional horse-power motor. As a part of the automatic weighing machine, the thrustors control the gates of the aggregate hoppers. Each is actuated by adjustable contacts mounted on the dial of a standard springless scale. Operator adjusts contacts so that each thrustor in sequence holds its respective bin gate open for a length of time determined by the setting, each amount of aggregate thus weighed automatically totaled to a predetermined value. MS (2.03)

Temperature (2.06)

The Use of Thermo-Couples at High Temperatures. (Ueber die Verwendung von Thermoelementen in hohen Temperaturen.) A. SCHUEZE. *Zeitschrift Verein deutscher Ingenieure,* Vol. 75, June 6, 1931. p. 731-733.

A few recent thermo-couples are described of which the Heraeus couple "32/40" consists of an alloy of gold, palladium and some platinum against a platinum alloy and has, over a range of from 0° to 1200° C, a considerably higher (about 5 times) EMF than the Le Chatelier element of platinum-platinum-rhodium, but its proportionality is poor. Another couple of Nickel-Nickelsteel can be used up to 1100° C and one of nickel-carbon up to 1200°; the EMF of both is about half of the constantan-ion couple which, however, is good only up to 900° C. For very high temperatures above the melting point of platinum a couple of pure tungsten and 75% W with 25% Mo has been made which is good for 3000° C; this couple, however, reverses its direction of EMF at about 1200° C. At 500 to 700 volt it has 1.0 mv. and at 3000° — 6 mV. Ha. (2.06)

Measurement and Control of Temperature in the Hardening Shop. (Temperaturmessung und-regelung in der Harterei.) A. GRUNWALD. *Feinmechanik und Prazision.* Vol. 39, Oct. 1, 1931, pages 151-156, Nov. 1, pages 179-183.

The importance of exact temperature measurement and temperature control particularly in the hardening process is pointed out; the hardening heat must not exceed the absolutely necessary, it must last a certain time and only long enough for all parts to have assumed uniform heat. Tempering must be carried out at a certain temperature best suited for the particular steel. If these precautions are not observed, hardening cracks occur, the steel is overheated and is burnt, or an upsetting effect takes place. The instrument for the supervision of this process, radiation pyrometers, thermocouples, resistance thermometers, and their accessories are thoroughly treated, their principles explained and connections illustrated. Ha. (2.06)

TESTING & INSPECTION (3)

Production Testing & Inspection (3.2)

A Study of Comparative Results for Lea, Single Thread, and Ballistic Tests on Yarns from Standard Indian Cottons. A. J. TURNER AND V. VENKATARAMAN. *Journal of Textile Institute Transactions,* Vol. 22, April 1931, p. T197-T223.

The three methods of testing are explained and compared by placing the staple cottons of each season in their order of rank according to each test. It is found that all the tests agree fairly well together but whereas the differences between the lea strength and single thread strength results are negligible, the difference between the ballistic strength results and those of the other tests are more serious. The ballistic test is recommended for a much more extended examination. Ha. (3.2)

A New Dynamic Wheel-Balancing Machine. (Eine neue dynamische Radausnoucht Maschine.) D. HOFMANN. *Automobiltechnische Zeitschrift,* Vol. 34, May 20, 1931, p. 335-337.

Describes an arrangement which permits detecting in a rotating mass of 40 kg. an unbalance of 1 g; the machine is built by the Hessische Maschineufabrik Robert Kunze, Darmstadt. Ha. (3.2)

Correction for Gear Tooth Calipers. NIKOLA TRBOJEVICH. *American Machinist,* Vol. 74, April 9, 1931, pages 573-574.

Gives formula and tables for rapid calculation of correction necessary when measuring gear teeth with calipers. RHP (3.2)

Accuracy in Gear Gaging. J. A. POTTER. *American Machinist,* Vol. 74, Feb. 19, 1931, pages 325-327.

Describes and illustrates in detail a micrometer method of gaging spur, helical, and level gears. Many gages only compare tooth profiles while this method based on true gear form measures any variation from this standard. RHP (3.2)

ELECTRICITY & MAGNETISM (4)

Electrical Properties, Tests, Measurements & Measuring Instruments (4.1)

Astatic Precision Instruments. (Astatische Präzisions Instrumente.) P. WIESSNER & P. M. PFLIER. *Siemens-Zeitschrift,* Vol. 11, Oct. 1931, pages 444-448.

In the use of precision instruments for electric measurements exterior fields which may superimpose themselves to the field of the instrument itself can destroy entirely the value of the high accuracy of the precision instrument. It is discussed how such exterior influences can be kept in proper limits by suitable screens and strong fields in the instrument, and especially by the arrangement of an astatic magnetic system. The letter arrangement as made by the Siemens & Halske A. G. is described in detail. Ha (4.1)

A Resistance for the Measurement of Very High Voltages. (La realisation d'une resistance pour les mesures en tres haute tension.) P. DE LA GORCE. *Revue Générale de l'Electricité,* Vol 29, March 14, 1931, pages 427-428.

The arrangement of a wire of 0.1 mm. is described which permits measurements at very high voltages without the disturbing capacity effect and great phase difference between voltage and current. Ha (4.1)

Mirror Galvanometer. (Spiegelgalvanometer.) *Elektrotechnische Zeitschrift,* Vol. 52, Oct. 22, 1931, page 1337.

A description of a portable instrument for demonstrations made by Gebr. Ruhstrat, Goettingen; the plane-parallel mirror has a diameter of 14 mm. Distinct readings can be made on a screen at a distance of even 10 m. Ha (4.1)

Construction of the Equivalent Resistance of Parallel Resistances. (Konstruktion des Ersatzwiderstandes parallel geschalteter Widerstände.) HERBERT KIND. *Elektrotechnische Zeitschrift,* Vol. 52, April 9, 1931, pages 477-478.

Describes a simple geometrical method with compass and ruler for the determination of the equivalent resistance for parallel vectors of the same and of opposite direction, and of any kind of direction of vectors. Ha (4.1)

Measurement of Dielectric Losses for Three-Phase Current. (Messung dielektrischer Verluste bei Dreistrom.) K. POTTHOFF. *Elektrotechnische Zeitschrift,* Vol. 52, April 9, 1931, pages 474-477.

Three-phase dielectric losses are measured by inserting the primary coils of inductances in the leads from the feeding transformer to the cable to be examined. The current in the primary coils induces in the secondary coils, connected to ground, voltages which have a phase difference of 90° against the primary current and are proportional to the primary current. These voltages are used for various bridge connections. It is proven that a so-called M-connection is correct and the application of this connection for the measurement of the losses in a three-phase cable is described. Ha (4.1)

Electric Meters with Mercury. (Les compteurs electriques a mercure.) V. NEVEUX. *L'Industrie Electrique,* Vol. 40, 1931, pages 253-261.

The meters of Ferranti Co., Chamberlain & Hookham, Cie. and Sangamo Co. are described in detail. Ha (4.1)

Method for Measuring Electric Power. (Methode de mesure de l'energie électrique.) N. KOPPEL. *L'Industrie Electrique,* Vol. 40, Jan. 10, 1931, pages 14-15.

A standard metre is described which has a terminal arrangement so that active and reactive power can be read provided the three phases are equally loaded. Ha (4.1)

The "Tonic Wind" Voltmeter. *The Electrical Review,* Vol. 108, May 1, 1931, page 771.

From the electric field of a highly charged point electrons are emitted which in their movement collide with uncharged molecules of the air, thus imparting to them velocity and causing in effect, a "wind." This effect was investigated, it has a cooling action on a wire enclosing a charged point. When the wire is made part of a bridge the out-of-balance voltage gives a measure of the field strength and the high voltage. Indoor and outdoor forms of such precision instruments for testing and X-ray apparatus have been developed. Ha (4.1)

Measuring Condenser with Linear Capacity from Exact Zero Upwards. (Messkondensator mit einer von exakt Null linear ansteigenden Kapazitat.) K. KUHLMANN. *Archiv Elektrotechnik,* Vol. 25, Oct. 12, 1931, pages 666-668.

The total capacity of this condenser is separated in two parts in such manner that one pole is common to both capacities while the second can be covered by a movable auxiliary pole of equal potential to such an extent that the free, not covered, part of the second pole can be brought down to exact zero. The dielectric is air, but also other materials may be used. Ha (4.1)

Measuring Ionization Currents and High Resistances. IRVING J. SAXL. *Electronics,* Vol. 3, Aug. 1931, pages 62-63, 86.

For determining the proper dosage of X-ray irradiation for therapeutical purposes an instrument, the "Mekapion," has been developed. It consists in principle of an ionization chamber connected across a condenser, and an inductance with two windings. If a certain ionization current flows through the chamber it opens a sensitive relay and this in turn interrupts the current in one winding of the inductance, thus inducing a current in the other winding which charges the condenser up again and closes the relay. This cycle repeats itself. The Mekapion can also be used as a recording instrument, the current for its operation is about 2 milliamperes. If, instead of the monization chamber, an insulating material is used, high resistances can be measured ranging from $1x10^9$ to $12x10^{13}$ ohms. Ha (4.1)

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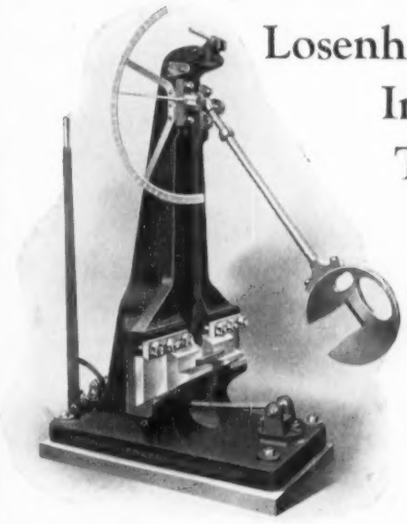

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The Measurement of Direct Currents of Great Intensity. (La mesure des courants continu de forte intensité.) P. GONNARD. *Revue Générale de L'Electricité*, Vol. 29, March 21, 1931, pages 457-463.

An iron circuit with an armature connected to a measuring instrument is placed around the conductor carrying the intense current; the iron is excited from an outside source and the fluctuations in the conductor provide an excitation of an inverse direction so that the galvanometer indicates the differences only of the E. M. F.'s produced by the fixed and variable excitations. The errors, compensation and methods of calibration are described in detail. Ha (4.1)

Watthourmeters. E. FAWSSETT. *The Electrical Review*, Vol. 108, June 19, 1931, pages 1043-1044.

A comparison is made of the latest induction watt-hour meters with those of a few years ago. While no principle change can be stated there has been distinct progress in detail and performance. Synthetic stones are now preferably used for supporting the rotor; a magnetic suspension of the rotor has not yet found a practical solution. Ha (4.1)

A Capillary Electrometer of Improved Design. A. S. GILSON, JR. *Review Scientific Instruments*, Vol. 2, June 1931, pages 329-331.

Describes in detail a vibration-free capillary electrometer which is very satisfactorily used as a null-instrument as well as for continuous photographic recording. Ha (4.1)

The Measurement of High Direct and Alternating Voltages. (Messen hoher Gleich -und Wechselspannungen.) H. GRUENEWALD. *Zeitschrift Verein Deutscher Ingenieure*, Vol. 75, Nov. 28, 1931, pages 1449-1454.

The various conditions under which amplitude and effective values of voltage have to be measured are met today by three groups of instruments: 1, instruments for which the high voltage is transformed to suitably low value; 2, instuments indicating the high voltage directly, and 3, devices for recording of the curve of high voltages and such which permit deriving kind and magnitude of voltage from the records. The first group comprises potential transformers and potential dividers, resistance and capacitive dividers. For the direct measurement, spark gaps and electrostatic instruments are employed; also the "electric wind" for very high voltages has been used. The recording instruments are the Reydonometer (with records in Lichtenberg's figures) and oscillographs; also piezo-electric properties have been used. Descriptions and illustrations of several instruments are given; 26 references are cited. Ha (4.1)

A New Type of Bridge Balance Indicator. F. T. MCNAMARA. *Review Scientific Instruments*, Vol. 2, June 1931, pages 343-347.

An arrangement with a thermionic tube current detector is described which is modified so as to be useful also for very small currents. Ha (4.1)

Surge Voltage Measurements with the Klydonograph in German High-Voltage Systems. (Ueberspannungsmessungen nit den Klydonographen in deutschen Hochspannungsnetzen.) H. NEUHAUS. *Archiv fuer Elektrotechnik*, Vol. 25, May 9, 1931, pages 333-358.

A resumé of surge voltage measurements made from 1927 to 1929 in systems of 15 to 100 KV. The arrangement of the tests, the instruments used, are described and the surges divided into such as thunderstorms, grounding in transmission lines, and switching phenomena. The frequency of excessive voltages due to thunderstorms and grounding decreases with increasing voltage; the relative magnitude of the surges is approximately the same for both kinds. The measurements in a station give a proper view of the magnitude of switching surges, the magnitude of grounding surges is measured slightly less and that of thunderstorm surges mostly lower than it is at the place of origin. A list of 22 references is added. Ha (4.1)

Wattmetric Oscillography. (Wattmetrische Oszillographie). WILH. PETERS. *Elektrotechnik und Maschinenbau*, Vol. 49, Oct. 18, 1931, pages 769-778.

The measuring system of a wattmeter-oscillograph is an electrodynamic wattmeter with stationary exciter coil and moving armature with a very small inertia, consisting of a single narrow loop of a phosphor bronze wire. An apparatus built by Siemens & Halske is described and oscillograms reproduced which show active and reactive kilowatts, exchange of energy between hunting alternators, equalization phenomena, etc. Some examples of evaluating these oscillograms are demonstrated. Ha (4.1)

Tube Voltmeter for Currentless E M F Measurement. (Rochrenspannungsmesser fuer stromlose E M K Messung.) E. BLUHM. *Elektrotechnische Zeitschrift*. Vol. 52, June 1931, page 772.

In order to eliminate the disadvantage of potentiometer measurements if the measurements have to be made very quickly, the following method has been proposed by Toedt and Thrun. Two electron tubes together with two resistances of about 10,000 ohms each form a Wheatstone bridge. The anode current for the tubes is supplied by a battery which also feeds the bridge. The inner resistances of the two tubes are equalized by a resistance parallel to one tube so that the galvanometer shows no deflection. If now an E M F is connected to the grid of the other tube the galvanometer will show a deflection proportionate to this E M F. The whole arrangement and how to calibrate it is described. Ha (4.1)

Insulation-Resistance Indicator. *Electrical Review*, No. 13, 1931, page 743.

Describes "Bullen" insulation indicator introduced by Brookhirst Switchgear, Ltd., Chester, England. Shows at a glance when the insulation resistance of an installation has fallen below a safe value. Designed for use by unskilled workers. It consists essentially of a glow tube used in combination with resistances and a switch having the following positions: "Warning" in which the glow tube shows a light if the insulation resistance falls to 0.75 megohm: "Danger," in which the tube will light up only if the resistance has fallen to 0.25 megohm; "Pilot," in which the tube shows a light if a supply is available at the starter; and "Off," which can be used to indicate at a distance that the motor is about to start or to signal a switchboard operator that the main switch needs to be closed. MS (4.1)

High Voltage Measurements. *The Electrical Review*, Vol. 108, Feb. 20, 1931, page 325.

Reports of papers read before the Institution of Electrical Engineers, dealing with methods of ascertaining peak values by condenser-dividers with rectified low-voltage, neon tubes meters with capacitance potential dividers and sphere-gap calibrations. The various methods available for high-voltage measurements are described and their accuracies and convenience discussed. Ha (4.1)

Measurement of Small Ohmic Resistances. (Messung kleiner ohmischer Widerstände.) JOS. KROENERT. *Archiv für Technisches Messen*, 1931, section V3511-1, page T10.

Resistances below 0.1 ohm are determined with good accuracy by the cross-coil instruments, compensating method, method of Matthiesen-Hocking, Thomson bridge, differential galvanometer, which methods are all described briefly. Ha (4.1)

Alternating Current Bridges of the Anderson Type. (Wechselstrom-Brücken vom Anderson Type.) JOS. KROENERT. *Archiv für Technisches Messen*, 1931, section J921-1, pages T29-30.

The theoretical principles are derived and the arrangements of Anderson, Stroud and Oates, Iliovici, Orlich, Butter, Worth, Schering, Hay, and others described. Ha (4.1)

Measuring Bridges. (Messbrücken.) JOS. KROENERT. *Archiv fur Technisches Messen*, 1931, section J910-1, page T46.

The theoretical principles of Wheatstone and other Bridge circuits are derived. Ha (4.1)

Electrical Measuring Devices & Applications (4.2)

Remote Measuring and Totalising of the Street-Railway Energy at the Municipal Electricity Works, Frankfort-Main. (Fernmessung und-summierung der Strassenbahnleistung bei den Stadtischen Elektrizitatswerken Frankfurt a. Main.) W. WEBER. *Elektrotechnische Zeitschrift*, Vol. 52, June 1931, p. 821-823.

Describes the arrangement along the compensation method of the A.E.G. in which the quantity to be measured is first converted, by comparison of two torques, into a direct current proportionate to the quantity and then transmitted to the remote central station. The output of seven substations are in this way controlled and summarized. Ha (4.2)

Measurement of Non-Uniform Rotary Motions with Piezo-Electric Crystals. (Messung ungleichförmiger Drehbewegungen mit piezoelektrischen Kristallen.) H. LUND. *A E G-Mitteilungen*, Dec. 1931, pages 694-697.

A device is described for the measurement of variable torques which is based on the measurement of the acceleration pressure by a mass carried along with the idling motor. The pressure exerted on this mass, which is proportional to the torque, is recorded oscillographically by means of quartz crystals; this is possible as these crystals have the property to produce on their surface an electric charge which is proportional to the pressure acting on them. Ha (4.2)

Voltage Testing of High Voltage Cables. (Spannungs-Prüfung von Starkstromkabeln.) H. MEHLHORN. *Archiv für Technisches Messen*, 1931, section V339-3, pages T39-40.

The methods using direct current and simple and multiphase alternating current testing are described in detail, the rules of the VDE are given in a table. 8 references are cited. Ha (4.2)

On a New Galvanometer Relay. (Ueber ein neues Galvanometerrelais.) S. REISCH. *Zeitschrift für technische Physik*, Vol. 12, Nov. 1931, pages 541-549.

The significant feature of this recent galvanometer relay is that the warping of a thin current conducting metal foil in a magnetic field is measured by a capacitive method. The sensitivity and the length of time to come to rest are computed. A device based on the principle of feed-back permits handling at random the damping of the measuring system. The ultimate sensitivity for a measurement based on only one reading is evaluated with reference to the theory of Ising & Zernicke and the possibility of extending this limitation beyond 10^{-10} volt/mm. is discussed. By integration of the recorded curves which clearly exhibit fluctuations, even higher sensitivities can be attained. Bibliography included. EF (4.2)

Current Transformers. (Stromwandler.) GEO. KEINATH. *Archiv für Technisches Messen*, 1931, section Z281-1, pages T31-32.

The construction and insulation of different types is described. Ha (4.2)

Current Transformers, Portable Types. (Stromwandler, tragbare Wandler.) GEO. KEINATH. *Archiv für Technisches Messen*, 1931, section Z285-1, page T15.

Different types, generally for not more than 30KV and about 15VA, are described. Ha (4.2)

Power Factor Correction by Means of Condensers. (Leistungs faktorverbesserung mittels Kondensatoren.) F. JACOBSON. *Elektrotechnische Zeitschrift*, Vol. 52, No. 50, Dec. 10, 1931, pages 1517-1519.

An installation of condensers of 5000 reactive KW., which will be increased by another 10,000 reactive KW., is described. They have to correct the power factor at the end of a line of 106 km. length and 40 KV. Operating data and calculation of economy are added. Ha (4.2)

New Apparatus with Cross-Coil Bridges to Measure Heat. (Neues Brücken-Kreuzspul-Messwerk für wärmetechnische Messgeräte). *Archiv für Wärmewirtschaft und Dampfkesselwesen*, Vol. 12, June 1931, page 178.

Describes apparatus consisting of 2 coils on one axis, a main and a direct coil, both connected to the same current source, and acting in opposite directions but complementary to each other. Put out by Siemens & Halske. MAB (4.2)

Automatic Oscillograph Records of Short Circuits. *Electrical World*, Vol. 98, July 11, 1931, page 88.

Accidental short circuits and similar phenomena are recorded by a new oscillograph, designed as type PM-13-A 1, manufactured by the General Electric Co. It contains 6 galvanometers of standard construction and makes an oscillographic record on sensitized paper 4½ in. wide. The ability to start the record in less than a half cycle is a feature. The instrument may be mounted on a table or on a switchboard panel. WHB (4.2)

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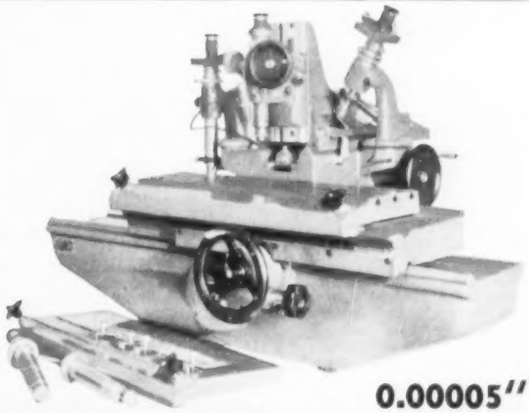

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High-Voltage Test-Transformers. (Ueber Hochspannungs-Prüftransformatoren.) W. Gauster. *Elektrotechnik and Maschinenbau*, Vol. 49, Nov. 1, 1931, pages 809-814; Nov. 8, pages 828-831.

Different types of arrangement of winding and cores and the insulation for voltages up to 2,000,000 volts and oil and air transformers for power and X-ray practice are described. Ha (4.2)

Differential Connections for the Electrical Integration of Heat-Magnitudes by Means of Resistance Remote Transmitters and Induction meters independent of voltage. (Differentialschaltungen zur elektrischen Integrierung warmtechnischer Messgrossen mit Widerstandsfernsendern und Spannungsunabhängigen Induktionszahlern.) W. Geyger. *Archiv fuer Elektrotechnik*, Vol. 25, Nov. 12, 1931, pages 769-775.

An arrangement is described in which the current transmitted to the remote station itself assumes the function to compensate for eventual fluctuations of voltage. The theory of the method is derived and the application for one or more instruments explained. Ha (4.2)

Manometers and Thermometers with Electric Contacts (Manometer und Thermometer mit elektrischen Kontakten.) K. W. Geisler. *Zeitschrift Verein deutscher Ingenieure*, Vol. 75, April 4, 1931, page 431.

For giving optic or acoustic signals; made by Haenni & Co., Jegenstorf, Switzerland. Contacts are made in mercury. Ha (4.2)

An Instrument for Measuring Small Displacements. B. F. Langer. *Review Scientific Instruments*, Vol. 2, June 1931, p. 336-362.

This instrument was devised for the measurement of very small displacements due to vibrations or strains from dynamic loads. It consists in principle of two rigidly fixed laminated iron cores between which a laminated iron armature is arranged movably with respect to the two cores. The two cores together with two resistances form a Wheatstone-bridge the equilibrium of which is disturbed by a movement, however slight, of the armature. The method of calibration and application is described in detail and curves taken with the instruments reproduced. Ha (4.2)

Winding Calculations Reduced to Single Slide-Rule Setting. W. O. Hurlbut. *Electrical West*, Nov. 1, 1931, pages 228-229.

Presents simplified methods for working out winding data for commercial polyphase motors. Permits easy, rapid calculation of turn per phase and wire size for any given frame size. Results obtained are well within the necessary commercial accuracy. MS (4.2)

New Portable Oscillograph by André Blondel. (Nouvel oscillographe portatif de Mr. Andre Blondel.) J. Vassiliere-Arlhac. *Industrie Electrique*, Vol. 40, Aug. 25, 1931, pages 368-372. Revue *Générale de l'électricité*, Vol. 30, 1931, Oct. 24, pages 669-677.

A detailed description of the instrument is given which is equipped with a specially strong optic system. A few curves of electrical and metallurgical measurements and an electrocardiagram illustrate the quality of the curves taken. Ha (4.2)

The Application of the Protos Vacuum Switch for Temperature Regulation. (Die Verwendung des Protos-Vakunmschalters zur Temperaturregelung.) Werner Jubitz. *Siemens-Zeitschrift*, Vol. 11, Oct. 1931, pages 472-481.

This regulator is intended for the regulation of the temperature of electrically heated bodies, and consists, in principle, of a metal strip the heat expansion of which against an approximately invariable strip is enlarged 20 times and operates a vacuum switch. The operation for several purposes is illustrated. Ha (4.2)

The New Voltage and Polarity Tester for Electrical Installations. (Die neuen Spannungs-und Polprüfer für elektrische Anlagen.) F. A. Foerster. *Elektrizität im Bergbau*, Vol. 6, April 22, 1931, pages 65-67.

The new neon-testers have the advantage over the formerly used test lamp that they can be used for any voltage up to 750, they show whether a. c. or d. c. is in the system and, in the latter case, which polarity. They are made by several manufacturers. A few constructions and the method of their application are described. Ha (4.2)

A New Highly Sensitive Standard Frequency Recorder. (Ein neuer hochempfindlicher Normalfrequenzschreiber der Hartmann & Braun A. G.) E. Blamberg. *Elektrotechnische Zeitschrift*. Vol. 52, June, 1931, p. 811-813.

The instrument is a dynamometer for very weak alternating currents composed of air core iron (laminated) core with a cylindrical bore in which three windings on iron cylinder are suspended; one winding is in series with an air condenser, the other with a high inductance, and the third is short-circuited in itself. Condenser, inductance and resistances are so adjusted that no directive force is exerted in the zero position and that temperature and voltage fluctuations are eliminated. The error of the instrument is only $\pm$ 0.02 Hz. The construction of the instrument is described, a few records reproduced. Ha (4.2)

ELECTRONICS & RADIO (5)

Photo-electric Measurements, Devices and Applications (5.3)

New Types of Photoelectric Cells. A. R. Olpin. *Bell Laboratories Record*, Vol. 9, March 1931, pages 310-314.

A brief history of the development of photoelectric effect since its discovery by Hertz in 1887 is outlined. At present, such cells are made of the alkali metals Na, K, Ru and Cs which are especially treated on their surface to make them as uniformly sensitive as possible for the whole range of vision of the human eye. The response curve, however, does not necessarily have to be similar to the eye, it is quite sufficient that there is a response to difference in average light intensities; the cell giving the greatest output per unit of incident energy is the most desirable for such purpose. To obtain this the surface of the alkali metals are treated with gases or vapors; different methods are described and the curves of their response reproduced. The uses of these calls in sound pictures or picture transmission and two-way television is explained briefly. Ha (5.3)

Literature Research

(Continued from page 112)

section is published on X-rays under the title *Röntgentechnische Berichte*.

Finally, there are several abstract services in the metallurgical field, of which a very complete and elaborate one is the Metallurgical Abstracts Section of the magazine *Metals & Alloys*. Sections 6—Physical, Mechanical, Magnetic Testing; 7—Inspection; and 28—Instruments and Controllers, are particularly rich fields for research in the measurement or control problems in metallurgical engineering.

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An Electronic Tool

(Continued from page 114)

trate, let the spaced condenser plates of a 1,000,000-cycle-per-second oscillator be moved but a millionth of an inch further apart. The resulting change in *amplitude* of the oscillatory current can be made to give a full inch meter deflection by any one of three different methods: circuit resonance, and the methods of Dowling or Reisch.[4] Similarly, the slight change in frequency produced by adding one millionth of an inch to the spacing of the oscillator's condenser plates can be readily measured by the methods of Whiddington, or Loebe and Samson.[4]

Five different methods are available then to use the electron-tube oscillator as an ultra-micrometer, and each of these ultra-micrometers has untold applications. Loebe and Samson used theirs to continually gage fine wire. The ultra-micrometer of Gerdien was applied to measuring lathe tool pressures and vibrations.[5] Whiddington's ultra-micrometer successfully measured millionths of a gram and indicated temperature changes of a thousandth of a degree.[4] Dowling applied the electron tube oscillator in the function of an ultra-micrometer to measure the growth of plants, and Ekelof used Dowling's adaptation to measure vibrations producing fatigue in metals.[4]

Non-Contacting Response

The other basic characteristic of the oscillator which makes it a very versatile measuring and controlling tool is this: The magnitude of any one of the elements comprising an oscillator depends, in effect, on the bodies near to it. Thus a body of metal near the coil or leads of an oscillator's tuned circuit effectively increases its resistance. Similarly, the magnitude of the oscillator's condenser is altered by the amount of dielectric material present between the condenser plates, even though this material does not touch the plates.

The change of resistance due to a metal body near the oscillator finds one application in a control for passenger elevators. When the elevator is near the desired level, a metal vane fixed to the car passes an oscillator coil, and in passing so increases the coil's effective resistance, that the resulting change in current generated by the oscillator is enough to cause the operation of a relay, which stops the elevator.

Along this line also is a chronograph application in which an oscillator coil "senses" a metal pendulum bob each time the bob swings past, and in response operates a recording relay. The pendulum swings are thereby recorded as if the coil were an "electric eye," seeing each swing and recording what it sees.

Change of the oscillator's condenser with the amount of dielectric material present between the condenser plates is made use of in a machine called the "Rubber

(Continued on page A17)

Temperature Control
FOR SMALL OBJECTS

The temperature of piezo-electric quartz crystals used to stabilize the frequency of vacuum-tube oscillators is held to within 0.1° C. The temperature-control boxes used with this equipment are also adapted for other constant-temperature purposes.

General Radio TYPE 547 Temperature-Control Boxes have a mercury thermostat that can be adjusted to operate over a wide range of temperatures. At 50°C., for instance, the temperature of the controlled space remains within 0.1° of 50° for a room temperature variation of ± 20°C.

Write for Details

GENERAL RADIO COMPANY
CAMBRIDGE A, MASSACHUSETTS

Verigraph." The condenser plates are a fixed distance apart and a rubber sheet is passed between them. The oscillator current changes with the thickness of the rubber sheet passing through, and a meter reading the current changes indicates the gage of the rubber sheet.

To measure the moisture in grain by this same principle, one places in the space between condenser plates the same amount of successive samples, and observes the reading of the oscillator current meter, which is previously calibrated in terms of moisture content.[6] This makes the oscillator more than an electric eye—an electric X-ray, which not only *sees*, but *sees into* materials.

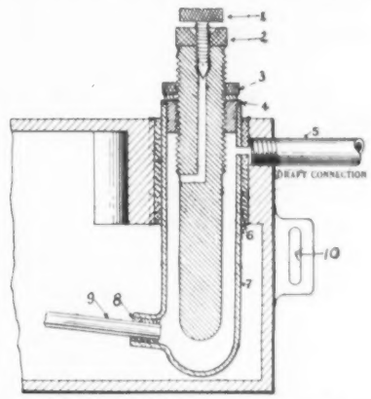
Speeds

One commercial device which uses an oscillator to study the speed of a rotating or vibrating body is called a Stroboglow. The oscillator output is connected to the contacts at T (see diagram). The neon tube g then flashes at the frequency of the oscillator output. Since the oscillator is calibrated and its frequency is variable, the frequency of the light flashes can be adjusted until the vibrating or rotating object appears to stand still. The frequency of the vibrating or rotating element being viewed is then the same as the frequency of the neon lamp flashes, and this frequency can be read off calibration charts provided with the oscillator.

In this way the apparatus can be used to locate and determine the frequency of vibrations in automobiles at various running speeds. The car to be studied can be placed on a tread mill arrangement and run at the desired speed. It would then be viewed with the Stroboglow light, and the oscillator tuned so that any vibrating part seen would appear still. By referring to the oscillator calibration curves, the frequency of the vibration could be determined.

(Continued on page A18)

Defender Patented DRAFT GAUGES



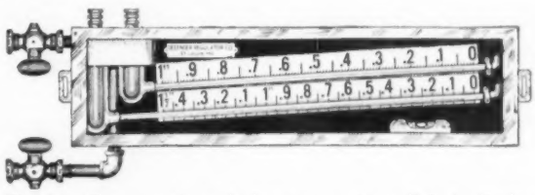
The above sectional view shows the latest improved type all metal Nickel Plated, Oil Chamber now used on all Defender Draft Gauges, as same is cemented into the Cast Aluminum frame of the Gauge.

It is equipped with a PATENTED combination Hollow Oil Filling and Oil Leveling displacement plunger, for screwing down into the oil so as to level the oil to the 0 or zero mark on the scale.

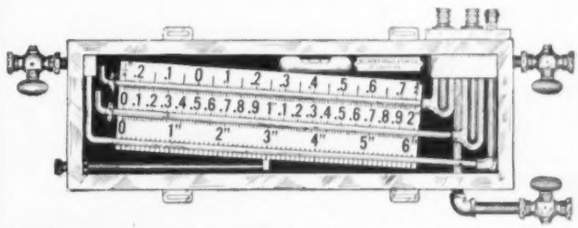
We claim this important improvement removed the last objection there was to the Inclined Tube Oil Filled Draft Gauge and is one of the most important improvements since the first AMES inclined tube Draft Gauge appeared on the market in Chicago about 35 years ago.

Above is shown the latest improved type of Defender 1-in. large size single tube Draft Gauge in the right hand and same is also supplied in the left hand Gauge.

It is equipped with the new large size all white Scale reading in hundredths and tenths of an inch of water vacuum. The Gauge is also supplied with any Scales from half-inch to 3-in. or in compound scales.



The above illustration shows the latest improved type Defender Duplex Draft Gauge, in the left hand type and same is also supplied in the right hand type. The top scale is 1-in. for reading Furnace Draft, the bottom scale is 1½-in. for reading Draft at last pass of the boiler below the damper. Any combination of scales can be supplied up to 3-in.



Defender 3-tube combination Draft and pressure Gauge for forced Draft Stokers or Furnaces, made in both right and left hand Gauges with any combination of scales.

Inclined tube Draft Gauges for every purpose are shown in new Bulletin No. 28 and Pointer Type Draft Gauge in New Bulletin No. 33 Portable Gauges Bulletin 32 and Manometers Bulletin 36 and 38.

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Mfg. Combustion Control Systems and Efficiency Instruments for Fuel Saving in Boiler Rooms.

INSTRUMENTS INDEX

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If you are unable to find what you require in this section of INSTRUMENTS—write Information Section, Instruments Publishing Company. Give complete information of requirements.

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Summary

All these applications can be summed up in naming the electron-tube oscillator a tool useful for:

a) Extremely fine length measurements.
b) Measurement without contacting the object measured.
c) Measurement of the properties within a product—moisture of grain, for example—by measurements conducted entirely outside that product.

In closing, one might characterize the versatility of the oscillator as a measuring or controlling tool by asking, not "What *can* it do?" but "What *can't* it do?"

References

[1] The Michelson Velocity of Light Experiment. E. C. Nichols. *General Radio Experimenter*, Vol. 6, March 1932.
[2] Electron Tube Oscillators With Feed-Back Coupling. C. K. Jen. *Proceedings Institute of Radio Engineers*, Vol. 19, Dec. 1931, pages 2109-2144.
[3] A Recent Development in Vacuum Tube Oscillator Circuits. J. B. Dow. *Proceedings Institute of Radio Engineers*, Vol. 19, Dec. 1931, pages 2095-2108.
[4] Ultra-Micrometer Measurement by Radio. H. Olken. *Instruments*, Vol. 5, Feb. 1932, pages 33-36.
[5] Pressure Measurement. Dr. George Keinath. *Archiv für Technisches Messen*, Vol. 1, July 1931, pages T6, T7.
[6] Determination of Water in Foods, Condiments, etc. B. Bleyer & W. Braun. *Zeitschrift für Analitische Chemie*, Vol. 83, 1931, pages 241-268.

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Spectrometry (7.5)
Photography (7.6)
Microscopy (7.7)
Electromagnetic Rays (This heading covers all electromagnetic rays other than visible light: infra-red, heat rays, ultra-violet, X-rays, alpha, beta, gamma, cathode, and cosmic rays.) **(7.8)**
CHEMISTRY (8)
Under this heading will be chemical measurements, analysis, and their control applications.
ASTRONOMY, NAVIGATION, AVIATION (9)
Included in this section will be, besides usual matters concerning astronomy, navigation and aviation, special matter on direction-control such as range finding, direction finding, radio beacons, etc.
GEODESY, GEOLOGY (10)
In this section will be covered seismology, geophysical prospecting methods, etc.
INSTRUMENT DESIGN and CONSTRUCTION (11)
Matters concerning new instruments, their design, operation and manufacture, will be included under this heading.
GENERAL and MISCELLANEOUS (12)
This section will include: First; general items of interest to all in the field of measurement and control. Example—"Possibilities of Vacuum Tubes for Application to Measurement and Control" is an article of universal interest in the fields of measurement and control. Second; miscellaneous items of general interest because not includable under any of the above classifications. Finally, items of general interest to all fields of measurement and control, such as historical material, biographical, etc.
General (of interest to all in measurement or control fields) **(12.1)**
Miscellaneous (12.2)
Historical and Biographical (12.3)
Bibliographical (12.4)
Economic (12.5)
CONTROL FUNCTIONING EQUIPMENT (13)
Literature on the equipment used by operators or automatic controllers to perform their control functions will be covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."
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Electrical Control Functioning Equipment (13.2)
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Deformation
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Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Hays Corporation
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bausch & Lomb Optical Co.
Flow
Morey & Jones, Ltd.
Grinding
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Ellison Draft Gage Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Morey & Jones, Ltd.
Republic Flow Meter Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Brown Instrument Co.
Foxboro Co.
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Federal Products Corp.
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Foxboro Co.
Alfred Suter
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
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Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
Foxboro Co.
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Tagliabue Mfg. Co., C. J.
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Baldwin-Southwark Corp.
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Foxboro Co.
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Brown Instrument Co.
Foxboro Co.
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Brown Instrument Co.
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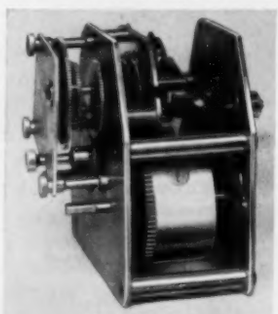

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See Tachometers

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Foxboro Co.
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General Radio Co.
Jewell Electrical Inst. Co.
Rawson Electrical Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Inst. Corp.
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General Electric Co.
Westinghouse Elec. & Mfg. Co.
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Jewell Electrical Instrument Co.
Rawson Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Inst. Corp.
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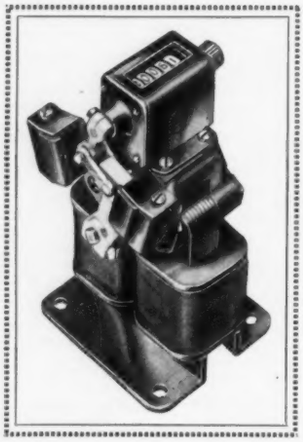

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